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THE FALL OF PORT ARTHUR.

In the fall of Port Arthur, which event occurred on November 22, 1894, China suffered a severe blow, as her navy was crippled by the loss of this great storehouse. In the eyes of the military experts the taking of this fortress will reflect greater credit upon the Japanese than any of the previous exploits on land, as the place naturally possessed great defensive capabilities and had been fortified by European engineers, so that it was considered well-nigh impregnable.

Port Arthur was the strongest and most important naval arsenal in north China. It lies at the extremity of the peninsula between the Gulf of Corea and the Gulf of Lian Tong, and is almost due north from Chefoo. The garrison when on a peace footing was 4,000 men, but at the commencement of hostilities it was greatly increased. On the sea front Port Arthur was guarded by a number of powerful forts. Twelve of the coast batteries were mounted with about 40 Krupp rifles, ranging in caliber from six to nine and a half inches. In addition to these rifles, there were rifled mortars and a large number of rapid-fire guns. The harbor was protected by a number of torpedoes.

The East Port of Port Arthur is divided from the West Port by a narrow strip of land called the Tiger's Tail, near the end of which is a strongly garrisoned fort. Breastworks dot the strip and end at the base where Fort Wei Yuen is situated.

Aside from the strength of the forts at Port Arthur, the point is of immense value, owing to the complete equipment of its dry dock. This is of most modern design and is 385 feet long and 80 feet wide.

It opens into the East Port, which is in reality only a large basin. About this basin are arranged many efficient workshops fitted with valuable engines and machines. The yards about the shops are threaded with railroad tracks and ways for traveling cranes.

On the land side Port Arthur was but weakly defended by a stretch of camps and trenches and earthworks, but these have recently been strengthened.

The approach to Port Arthur is through a channel not 200 yards wide at its narrowest point and hardly more than 300 yards wide elsewhere. The direction of the channel is northward.

Opposite the fort on the Tiger's Tail is one on the mainland, and these command the entrance, which is about 750 yards away.

The attack on Port Arthur began November 21. The right division stormed and captured the fort to the westward of the artillery parade ground. It then advanced in the direction of Port Arthur and captured Fort Kohinson. The left division took the fort southeast of Hachiviso. On November 22 the two divisions took all the other forts. The Chinese garrison numbered 80,000 men. The united squadrons merely attracted the attention of the enemy's seaward batteries. It was almost wholly a land fight. Before Port Arthur fell, Marshal Oyama had been gradually investing it for two weeks. In addition to enormous quantities of supplies, the Japanese gained important advantages by being in possession of dry docks, where their vessels could be refitted without sending them back to Japan.

For our engraving, which is from a sketch by Lieut. W. H. Thring, R.N., we are indebted to the London Graphic. It represents transports entering the inner harbor immediately after the hoisting of the Japanese flag.

DRAWN BY C. W. WYLLIE. FROM SKETCHES BY LIEUT. W. H. THRING, R.N.

PORT ARTHUR—JAPANESE TRANSPORTS ENTERING THE INNER HARBOR.

THE BASKETWARE INDUSTRY OF UPPER FRANCONIA.

THE United States commercial agent at Bamberg says that, nestled among the mountains of Upper Franconia, Bavaria, near the boundary line of Thuringia, is the small town of Lichtenfels, and very few of the travelers who, in journeying from Munich toward Leipsic, pass this apparently insignificant place are aware of the fact that here is situated one of the largest basketware markets in the world. The export from this market, both to European countries and to the United States, is of very considerable importance, and there is hardly a firm to be found dealing in this description of goods in the inland towns of Germany which does not order from Lichtenfels.

The origin of the basketware industry in Lichtenfels dates from the close of the last century, at which period a citizen of the place undertook the business of weaving baskets on a small scale, commensurate with the modest means at his disposal. The circumstance that induced him to begin the undertaking was the existence of a splendid growth of willow trees in the neighboring valley of the Main, thus furnishing him with the means of material for producing the article. At first the industrious basket weaver could find a sale for only the more primitive varieties of his merchandise, but the small farmers of the neighborhood who occupied themselves with basket weaving soon brought the art of producing baskets to such perfection that the founder of the new industry ventured to send his wares to the larger fairs and markets of the country, and even to seek additional purchases in foreign lands.

In spite of the fact that equally good material for manufacturing baskets was to be found in France, the latter country continued to order the German article almost exclusively until the outbreak of the Franco-Prussian war in 1870. Even at the present day Lichtenfels, Michelau, Hirschaid, and Burgkundstadt send basketware to the French market. The gradually increasing demands upon the young industry necessitated the securing of foreign raw material. The finer varieties of willow reeds had to be imported from Hungary and France, and even from countries beyond the sea, straw for the finer woven articles being ordered from Spain and Italy, and the palm leaves used for ornamenting the better class of wares from the tropics. In this manner the evolution of the so called house industry in Lichtenfels proceeded, resulting in the employment to-day of about 16,000 men, women, and children, who produce every imaginable variety of articles from the simplest to the most elegant. Factories, in the ordinary acceptation of the term, are very few in number. The basketware manufacturer delivers the raw material to the people who are to manufacture articles therewith at their own home, that is to say he weighs out for them the willow reeds, colored straw, palm leaves, etc., and gives them the designs, according to which the various articles are to be made, and at a stated time, generally on Saturday or Monday, the workers, who for the most part live in neighboring

villages, bring the products of their industry and skill to the manufacturer, receiving very small remuneration in return.

Apart from the low rate of wages, however, the basketware industry receives encouragement through the schools of design that have been established and are supported by the state, in which the young people of the neighborhood are educated in all branches of the industry. A child who has attended such a school is able, at the age of eleven or twelve years, to engage independently on basket weaving, or at least to aid the adults very materially in their labors.

THE TANNING SCHOOL OF SAXONY.

OF late years the tanning industry is said to have shown some signs of languishing in Germany, the competition with France and the United States being exceedingly keen. To remedy this, a tanning school —the only one in the world, according to the United States consul at Chemnitz—was opened at Freiberg, in the heart of Saxony. In Austria and France there are schools in which the chemistry needed in tanneries is taught, but there is no such school as that of Freiberg.

Freiberg has a population of 28,000. The school was opened in 1889, and its object is stated in its name. In it instruction is given in practical and theoretical preparation of leather, in tanning, and in finishing. It is supported by the state, which devoted to it the sum of 5,000 marks in 1893; by the city of Freiberg, which contributed 1,500 marks; and by friends, who gave it 2,385 marks. Besides money, presents of hides, rare pieces of leather, barks, nuts, etc., are sent to it, and also magazines and technical papers. Its scholars come from all parts of the world. Every year—since 1889—students from Prussia, Austria, Roumania, France, Meiningen, Russia, Holland, Switzerland, Bavaria, Oldenburg, and Saxony have been in attendance.

For practical work, the school is fitted up from cellar to garret with all kinds of machinery, from the steam engine furnishing power to the finishing machine that turns out the finest patent or calf leather. There are rooms and machines for the unworked skins, lime baths, vats, and cutting, rolling, pebbling, stretching, and pressing machines. It is stated that all the machinery used was made in the United States, and the director of the institution worked for ten years in the tanneries of that country. The students devote most of their time to studying tanning, preparing and finishing leather. They learn about oxygen, alkalies, carbohydrates, albuminoids, and fermentation. They study text books and hear lectures. In addition they work in the tannery and the laboratory.

Besides the director, there is a body of chemists and teachers, at the head of which is Dr. Von Schroeder. Under these, again, is a regular corps of practical tanners, who take a hide as it leaves the animal, through lime baths to the polishing rolls and processes, watched at every stage by the students. To this work the students give at least ten hours a week—two hours daily. Hides from all parts of the world are experimented on annually, and with all kinds of tanning, barks, and materials. The processes of the old and new schools are shown and compared. The former give good and the latter quick results; the former are expensive, the latter cheap.

The processes for softening, use of lyes, lime, arsenic, etc., for removing hair, etc., are gone into most minutely by men who have a great reputation for skill in their special lines. The articles used comprise oak, pine, quebracho, mimosa, valonia, sumac, and willow barks; extracts of oak, quebracho, hemlock, and gambier. The relative value, etc., of these barks and extracts are minutely examined, compared, and noted. The old vat or vault system is compared with the newer ones, in which the tanning is done by cold batteries, extracts, steam, and baths. Practical work is done on all kinds of machines. The school has a cutting machine, with a cutting surface of eight feet ten inches. It is stated that nothing is neglected, each department being as perfect as intelligence, skill, and money can make it. During the winter Dr. Von Schroeder and others give lectures. They treat of leathers, their qualities, etc., and how to distinguish the different kinds of dyes, extracts, and barks. Added to the foregoing are trips to tanneries, to woods to see the bark growing on the trees, to storehouses to examine the different descriptions of bark with a view to buying wholesale, and to experimental stations to examine processes or tests.

The studies and hours per week are as follows; Tanning and preparation of hides and leathers, twelve hours; chemistry and physics (especially relating to tanning), ten hours; bookkeeping, two hours; commerce and exchange laws, two hours; arithmetic, two hours; correspondence, one hour; drawing, two hours; freehand drawing, one hour; and mechanics, two hours. In connection with the question of tanning, Consul Monaghan mentions a curious fact, illustrating the wise and careful economy of the German people. Packages of tobacco sent from South America come usually done up in undressed hide boxes. These boxes are taken to the tanneries and training schools to be made up into leather. Besides being excellent illustrating material, they are stated to be the source of a considerable income to the tanning school.

IN a furnace with stationary hearth erected at Anzin, to produce steel of extra welding quality for tube manufacture, the bricks for the burners and roof are made of magnesite, and special precautions are taken to prevent the accumulation of dust in the checker work, by having straight passages without any projections. The cheaf feature of the process is the injection of cold air through the sides or roof, as well as the usual blast into the furnace to the extent of 5 to 15 per cent. of the weight of the air necessary for the complete combustion of the gas. The air jets are directed on to the metal bath by the use of inclined tuyeres, to lay bare the metal and to remove the glassy layer of slag or cinder from its surface, so as to facilitate oxidation. The air jets likewise cause an intimate mixture of the hot air and gas as they enter the hearth, and by so doing raise the temperature of the flame and direct it on to the surface of the metallic bath, the final result of the combustion being only slightly modified.

Number and Subjects of American Patents.

The recent annual report of the Commissioner of Patents contains an interesting and valuable table, showing the number of patents granted for the various subjects on which petitions have been filed. We herewith present this table in extenso. The total number of patents granted up to the close of 1894 was 511,744. The least number granted for any one subject was for linotyping, or type setting by machinery. The number of these patents is 98. The highest number of patents, on any one subject, is for carriages and wagons, for which the aggregate number of patents granted is 20,036.

TABLE OF AMERICAN PATENTS GRANTED FROM THE BEGINNING DOWN TO DECEMBER 31, 1894.

Brakes and gins	1,264
Bread, cracker, and lozenge making	764
Bridges	951
Brushing and scrubbing	3,184
Builders' hardware	7,742
Butchering	978
Caoutchouc and minor plastics	1,304
Carbonating beverages	278
Carding	1,520
Care of live stock	3,049
Carpentry	3,717
Carriages and wagons	20,036
Chains, staples, and horseshoes	942
Chairs	4,380
Charcoal and coke	179
Chemicals	1,143
Clasps, buckles, and buttons	11,705
Clay and pottery	3,000
Cloth finishing	659
Clutches	1,505
Coating with metal	454
Coin-controlled apparatus	318
Composite roofings and coverings	995
Conveyers	1,107
Coopering	970
Cordage	1,549
Cranes and derricks	506
Crinoline and corsets	1,506
Curtains, shades, and screens	2,436
Cutlery	2,103
Dairy	4,435
Dentistry	1,283
DESIGNS	
Draughting	697
Driers	2,681
Educational appliances	793
Electricity. Conductors	2,058
Electricity. Electric railways	1,751
Electricity. Generation	2,927
Electricity. Medical and surgical	393
Electricity. Motive power	1,051
Electricity. Special applications	493
Electric lighting	3,346
Electric signaling	1,781
Electro chemistry	2,253
Elevators	1,939
Excavating	2,165
Explosives	500
Furriery	1,284
Felt and fur	777
Fences	6,807
Fertilizers	434
Fine arts	1,500
Firearms	4,356
Fire escapes and ladders	1,407
Fire extinguishers	1,023
Fireproof buildings	455
Fishing and trapping	2,097
Fluid pressure regulators	802
Fuel	636
Furniture	4,264
Games and toys	4,453
Gas	3,000
Glass	1,351
Grinding and polishing	2,526
Hardware making	1,396
Harness	7,400
Harrows and diggers	4,691
Harvesters	10,155
Hides, skins, and leather	1,091
Hoisting	5,558
Horology	3,640
Hose and belting	1,002
Hydraulic engineering	1,146
Hydraulic motors	2,072
Injectors and ejectors	540
Iron structures	594
Jewelry	1,106
Journal boxes, pulleys, and shafting	4,362
Kitchen and table articles	1,747
Knitting and netting	1,580
Lamps and gas fittings	8,211
Laundry	7,033
Leather-working machinery	532
Linotyping	98
Locks and latches	5,979
Lubricators	1,409
Machine elements	4,785
Marine propulsion	1,562
Masonry	490
Matrix making	114
Measuring instruments	2,744
Mechanical motors	1,775
Medicines	1,320
Metal bending	656
Metal bolts, nuts, rivets and screws	2,206
Metal boring and drilling	1,242
Metal drawing	322
Metal forging	753
Metal founding	2,510
Metallurgy	4,685
Metal ornamenting	120
Metal personal wear. Making	461
Metal punching and shearing	1,006
Metal rolling	1,167
Metal tools and implements. Making	2,686
Metal tube manufacture	433
Metal turning, planing and milling	2,012
Metal welding	555
Metal working tools	3,266
Mills	9,720
Mineral oils	606
Music	3,928
Nails and spikes	1,573
Needles and pins	712
Nut and bolt locks	1,240
Oils, fats and glue	1,836
Optics	1,445
Ordnance	954
Packaging and dispensing liquids	1,262
Packing and storing vessels	10,854
Painting	2,043
Paper making	3,307
Paper manufactures	3,381
Paving	1,030
Photography	1,481
Plows	10,122
Pneumatics	3,647
Preserving	1,541
Presses	3,799
Printing	8,838
Projectiles	2,076
Pumps	4,240
Railway brakes	2,267
Railway draught appliances	6,780
Railway rolling stock	6,827
Railways	8,341
Refrigeration	3,408
Roofing	1,182
Safes	490
Seeders and planters	7,477
Sewerage	281
Sewing machines	6,048
Shaping fluid metal	735
Sheet metal ware. Making	2,266
Ships	2,743
Signals	2,162
Silk	106
Spinning	2,288
Stationery	4,532
Steam and vacuum pumps	827
Steam boilers	5,893
Steam boiler furnaces	2,947
Steam engines	8,237
Steam engine valves	2,465
Stone working	2,188
Store furniture	1,438
Store service	900
Stoves and furnaces	18,340
Sugar and salt	2,401
Surgery	3,535
Telegraphy	3,075
Telephony	2,297
Thrashing	4,130
Tobacco	2,274
Toilet	836
Towers	473
Trees, plants and flowers	924
Type writing machines	1,112
Umbrellas and canes	947
Undertaking	650
Vegetable cutters and crushers	2,005
Velocipedes	2,288
Wagon, car and track irons	1,074
Washing apparatus	669
Water distribution	7,707
Weaving	3,772
Wheelwright machines	710
Wind wheels	1,465
Wire working	1,449
Wood sawing	4,290
Wood turning	756
Wood working machines	5,524
Wood working tools	4,326

HOW SHALL THE TROLLEY BE APPLIED ON STEAM ROADS?

THE following is from the Electrical Engineer:

Our recent editorial on the changes which the substitution of the trolley for the steam locomotive is likely to bring about has elicited a number of communications on the subject, involving the methods best suited to the existing conditions of affairs. A number of these emanating from well known authorities are printed below.

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(1) I believe in the use of electric locomotives rather than the equipment of the individual cars.

(2) I do not believe in the use of the three-wire system for railways.

(3) I think the E. M. F. used should be not less than 200 volts per mile the power is transmitted.

(4) I believe the power should be produced and transmitted in the form of the alternating current, and that before being led to the moving contact it should be reduced to a pressure readily insulated, and then transformed upon the locomotive to a continuous current and used in this form in the propelling motors.

New York. H. WARD LEONARD.

In my opinion this work would naturally be begun by the placing upon the tracks, where it was desirable to do so, of self-propelled vehicles (motor cars), taking current from a trolley line above the tracks. This would enable frequent runs to be made between points at moderate distances apart, while it would not interfere with the use of the ordinary locomotives for the hauling of the usual trains. Such lines might come into use traversing only a portion of the existing railway with branches constructed for the passage of the electrically propelled vehicles to various points more or less remote from the existing line. In this way the railway companies might avail themselves of the advantages of the trolley and so constitute the trolley line branches as feeders for the main line, which latter may for some time to come preserve the character of a steam line.

Where, of course, a long train is to be drawn it may be desirable to use electric locomotives, particularly if the grades on the road are not great; or, perhaps, a compromise may be made in having one or more extra heavy motor cars at the head of a train controlled together and operated together, these motor cars taking the place of the locomotive itself, much as the motor car and trailer cars are used in the ordinary street railway traffic.

I think that without doubt a potential of 1,000 volts would be fensible for use and that the line could be maintained without undue leakages or accident, since the conditions of the placing of the line would naturally be more within the control of the operating company than is now the case in street railways.

The overhead system of placing the conductors seems to me to commend itself as the best, except, perhaps, in cases like the elevated roads with an elevated roadbed, in the control of the operating company, in which cases it would make very little difference where the conductor was placed, either above or below, or on low standards alongside the road, the chief thing to be looked after being that a sufficient insulation is maintained. The absence of crossings makes it feasible to place the conductor almost anywhere where it is found desirable to have it.

I think the three-wire system, using the track as the middle or neutral conductor, would not necessarily be applicable in all cases, but would probably be desirable for certain types of double track roads, particularly if the balance of traffic could be maintained on the two sides of the system.

For the heavier railway work over long distances it appears probable that transforming systems must be employed, in which the energy is carried at potentials of 5,000 to 10,000 volts and distributed by machines converting down to sections of the trolley line or low pressure feeding conductor. It may be possible, in this case, to use alternating currents with advantage on account of the transformers being so readily installed and handled, while the motors themselves can, with such a system, be of low potential, easily protected from leakages, commutatorless and directly carried on the driving axles, particularly where high speeds are to be attained. The means are now in existence for controlling the speed and obtaining variations of speed with high economy where several such motors are employed to drive a train.

Lynn, Mass. ELIHU THOMSON.

Concerning the methods which it is desirable to adopt in changing over steam railroads to electric railroads, we are of opinion:

(1) That at the outset each car should be equipped with an individual motor or motors, rather than have an electric locomotive draw a train of cars as in the existing steam roads. We are led to this conclusion because each car being a separate motor unit, will, at approximately the same expense, permit a greater number of cars to be run at more frequent intervals than is possible on a steam road, thus giving to the electric system the advantages now so clearly recognized as possessed by the individual trolley car, viz., short trains at frequent intervals, and consequently the commercial capability of stopping wherever passengers desire. It is probably this factor, as much as any other, which has caused the trolley system to be so popular.

(2) We would recommend that the limit of pressure employed on such lines with double track should be 1,000 volts, three wire, with ground return, that is, 500 volts on each track. Should it be found commercially desirable later on to raise the pressure to say 2,000 volts, this could probably be done without any change in the line construction.

(3) We would recommend that the conductor should be strung overhead, like existing trolley wires, at a sufficient distance above the roadbed to prevent accidental contacts. Placing the wires at any lower level would necessitate a change at grade crossings, as well as being more dangerous to life.

(4) We would recommend a single trolley wire over each track employing the rails as the neutral conductor. In order to do this, the rails should be thoroughly

connected and bonded. Where the number of cars is small and the length of the road great, so that a considerable distance might exist between adjacent cars on the up and down tracks, ground feeder wires would probably be essential.

At the outset, we would recommend broadly that it would be preferable to follow the present systems of trolley roads in the light of experience already gained, rather than attempt radical innovations.

HOUSTON & KENNELLY.

LABORATORY OF HOUSTON & KENNELLY,
Philadelphia, Pa.

THE THEATROPHONE.

FOLLOWING the introduction of the telephone, the idea occurred to devise an arrangement by means of which theatrical plays and opera music could be heard at home. It was in 1881, during the Exposition of Electricity, that the first public experiments were made. Since then the expositions of Munich, Vienna, Frankfort, and of Paris in 1881, have had their musical telephonic auditions in turn.

The success of these first experiments is easily explained, and the more so in that the difficulty of solving the problem was not very great, at least in principle, since it was a question simply of going from one

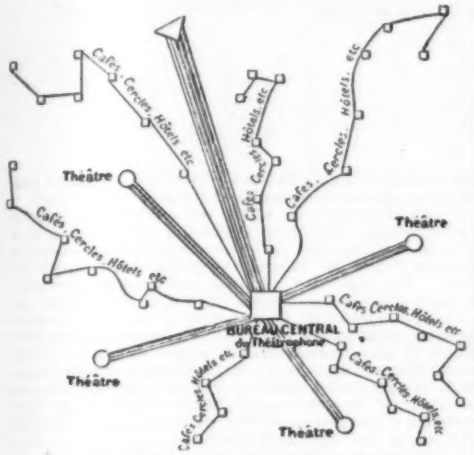


FIG. 1.—CENTRAL TELEPHONE OFFICE.

point to another through a special wire connecting the improved apparatus that were already at one's disposal.

The following were the arrangements adopted at the Paris Exposition of 1881:

Two halls, in the arrangement of which precautions were taken for deadening external noises, were, each of them, capable of accommodating twenty auditors, who had at their disposal twenty pairs of Ader receivers. The hearing lasted about five minutes. The transmitters were also of the Ader system. They were placed in the auditorium of the opera house, on each side of the prompter's box in front of the footlights, and to the number of ten on each side. Each of these microphone transmitters, supported by a leaden foot and separated from the woodwork by rubber, was

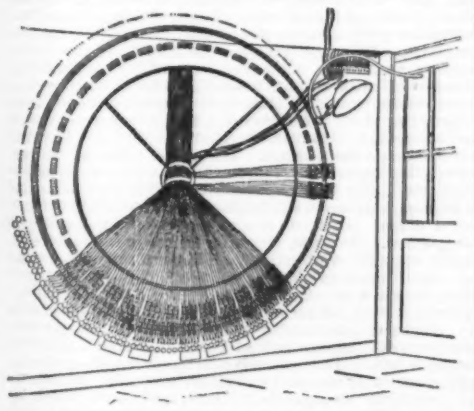


FIG. 2.—DISTRIBUTING BOARD.

actuated by a battery. An induction coil was in the circuit of a double wire line that ended at the receivers. In order to compensate for the difference of intensity of the sound produced by the presence of the singers upon the right or left of the stage, the receivers of a same pair corresponded to two microphones, one to the left and the other to the right of the prompter's box. In this way there was obtained a nearly constant resultant intensity, the right ear being more strongly influenced when the left ear was less so, and vice versa.

The question becomes complicated when it concerns the possibility of putting a series of theaters at the disposal of all the subscribers of the telephone system, and even of those who are not subscribers. Nevertheless, the thing has now been accomplished and the success is complete; and one can hear what is going on in a theater from any point whatever of France or from foreign countries connected with Paris by telephone. Such result is due to the initiative of Messrs. Marinovitch & Szarvady, who have succeeded in forming a company which, since its organization in 1882, has been constantly developing, and has always operated with the greatest regularity.

This company, for a certain amount of money, installs apparatus at the houses of the subscribers of the Paris telephone system that permit them to hear at home the plays produced at the different theaters. Each series of auditions gives rise to the collection of a fixed sum, whatever be the number of the auditors, the subscribers, moreover, being able to choose from among all the theaters connected with the telephone company, and having the faculty, too, of changing theater during the course of the same evening as many times as they wish. Hearings have likewise been provided for in a certain number of public establishments, such as hotels, restaurants, cafes, etc., by the aid of a special system of lines connecting these various centers in small groups with the central office of the theatrophone company.

There exists, then, at Paris, for the public establishments, a permanent service of auditions, by the aid of apparatus called theatrophones. For subscribers, hearings are afforded only upon their request. They may book themselves for a definite date, or else, what is most frequently the case, request an audition during the course of an evening.

Fig. 1, without faithfully reproducing the establishment of the lines just mentioned, nevertheless gives a sufficient idea of it to allow the installation of the system to be understood.

The central office of the Theatrophone Company is situated at No. 23 Louis-le-Grand Street, in a basement at which end the cables through which all the communications are made. These various cables are distributed between three categories of very distinct lines: (1) Those connecting this central station with the microphones placed in the theaters; (2) those connecting this station with the central office of the administration of telephones, where a communication may be established with all the subscribers of the system in France or foreign countries; and (3) those serving the audition apparatus placed in public establishments.

In each theater, microphone transmitters are arranged in front or behind of or even between the footlights. These apparatus are connected with a special room located near the stage, occupied by an employe of the Theatrophone Company and containing commutators and the microphones that receive the current of from six to eight Leclanche or Lalande and Chaperon elements.

From thence, according to the size of the theater and the probable number of requests for hearings, start a certain number of lines that at the central office of the company end in a distributing board (Fig. 2) where the different cables that we have before mentioned are arranged in order. We find here the lines that connect the office of the theatrophone with the theaters, the lines designed for the service of public auditions, the subscribers' lines, and, finally, what is called the city line, and which connects the company's office with the central state office for the service communications.

Starting from the distributing board, the different lines continue through paraffined wires and end at a switchboard comprising annunciators and conjunctors (Fig. 3). This board is completed by a crank commutator connected with repeating telegraphs in number equal to that of the lines of the theatrophones. Let us add that each hearing apparatus is provided with a dial that reproduces the same indications as those of the repeating telegraph connected with the line with which the said apparatus are connected.

The current utilized for setting these repeaters in operation, as well as the indications of the theatrophone system, is the same as that which supplies the incandescent lamps that serve for lighting. So the posterior face of the switchboard is provided with circuit breakers designed to prevent accidents. This current is derived from the general system of lines of the quarter.

Two employes are at present necessary for assuring the transmission of the auditions. One of them receives the communications of the subscribers, while the other, seated in front of the board, in proximity to the crank commutator, holds in her hand, as it were, the entire system of the theatrophones. It is her duty to

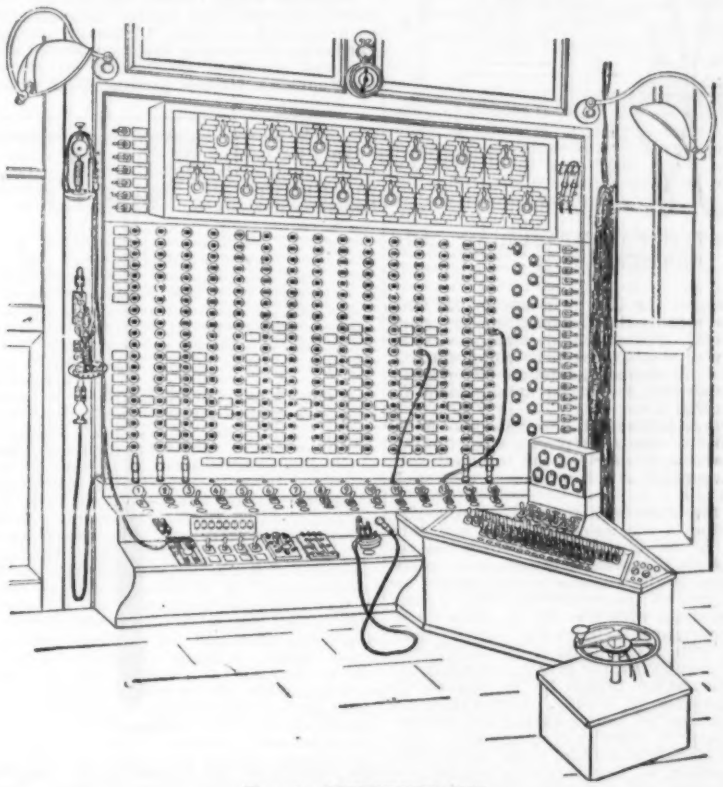


FIG. 3.—SWITCHBOARD.

control at a distance the service of the auditions at the houses of private subscribers, and also to change periodically the programme of the public auditions. As the repeating telegraphs reproduce the indications of the dials of the system of lines, the telephonist has merely to glance at her board in order to know what is being heard in such or such a place. Besides, she can control the proper working of the telephones by placing her apparatus (a Berthon-Ader) not directly in the circuit (which would uselessly increase the resistance of the line), but in proximity with it. The play of a lever provided with keys suffices to effect this operation. The telephonist then hears, through induction, feebly, but very clearly, all that is going on upon the line.

A measuring apparatus completes the installation of the central office and permits a special employe, exclusively charged with this service, to verify at every instant the state of the lines and to make sure that no derivation is intervening to weaken the normal intensity of the auditions.

In the public establishments a portable apparatus called a theatrophone can be installed upon collectors distributed through different halls, and so arranged as to give satisfaction to the demands of the patrons. The apparatus is placed in the circuit by means of a jackknife that enters a jaw provided with metallic contacts and attached to one of the extremities of a flexible cord whose other extremity is fixed to the wall. It is provided with telephone receivers, but remains mute until a coin has been introduced into a slot provided for the purpose.

In each establishment there is a dial telegraph similar to those that exist above the switchboard of the central office, and these automatic apparatus repeat the indication of the telegraph. As all the dials of the same line of theatrophones are set in operation simultaneously through the maneuver of the crank commutator, they indicate through the position of their needle the nature of the audition of the moment. It is therefore always possible to know what one is going to hear, and as the communications are frequently changed during the course of the same evening, one can wait for the moment in which the theater that he desires to hear is announced. The coin introduced into the apparatus, upon sliding into the money box, automatically establishes a connection between the line and the receiver, and, at the end of a certain time, another ungearing, by causing the coin to slide to the bottom of the box, interrupts the hearing, which the introduction of another coin renews.

During the moments (which are quite short and rare) in which all the theaters of the line are at the period of between acts a pianist makes himself heard in a hall in the vicinity of the company's central office, and all the lines of the theatrophone being then branched upon this music hall, all the dials give the indication of the piano. There can therefore be no surprise nor interruptions in the auditions.

The home service of the subscribers is performed very simply, the company being connected with the central telephone office by a large number of lines. It is by the employes of this office that the communication is established between the lines of the subscriber and one of the lines of the theatrophone company. Connection with the theater is made at the office of the company, upon the switchboard of which we have spoken.

The subscribers can listen to the performances either by means of the receivers of their telephones, or by means of special auditory apparatus that permit several persons to hear simultaneously without the distinctness of the sounds diminishing.

When a subscriber of the telephone line is connected with the theatrophone company for an audition, the employes of the central offices cut off the communications that are habitually left upon the lines.

The induction that would greatly decrease the distinctness of the hearing is thus avoided. An Ader re-

lay is interposed in the line at theatrophone company's central office.

This relay, in consequence of its feeble resistance and the absence of a core of soft iron, in nowise interferes with the telephone transmission. On another hand, it operates with so feeble intensities of current that the subscribers can, by means of the ordinary battery of their line apparatus, directly call Louis-le-Grand Street, whatever be the distance therefrom that they are situated.

The subscriber, thus connected with the theater, has therefore no longer any relation with the line, but, since he can always communicate with the central office of the theatrophone, it is easy for him to obtain thereby any communication that suits him. The telephonist of the theatrophone, moreover, can always have recourse to the intervention of the central telephone office, which she calls up by the city line.

In order to render it possible to measure at any in-

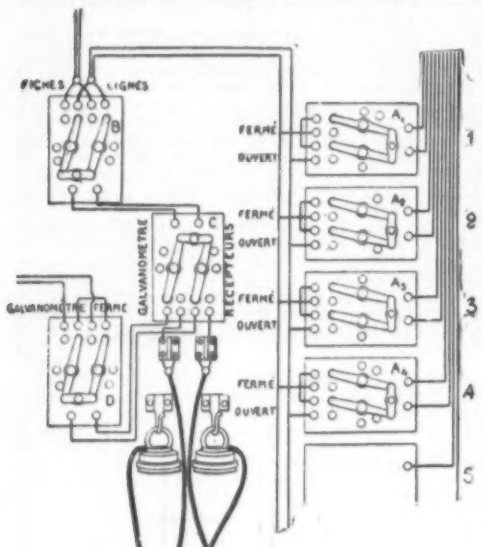


FIG. 4.—APPARATUS FOR MEASURING LINE RESISTANCE.

stant the resistance of the line of a subscriber who is listening, and so rapidly that he may not be aware of it, there is adopted an arrangement that consists in the use of a play of double direction commutators, A_1, A_2, A_3, etc., B, C, D, and a Wheatstone bridge with mirror galvanometer and scale, the arrangement of which is shown in Fig. 4.

The employe whose business it is to make the measurements has a list of the subscribers, opposite the name of each of which is inscribed the normal resistance of the line, according as it is connected with such or such a theater.

Let us suppose, for example, that he wishes to verify the state of the line of the subscriber who is listening upon line No. 3. He begins by regulating the variable resistance of his Wheatstone bridge, so as to obtain an equilibrium by the resistance that should be presented by the line of the subscriber who is connected, say this evening, with line No. 3. This done, he places the commutator A_3 upon the "open" indication, and then, with his eyes fixed upon the luminous index of the scale in front of him, he connects the line with the Wheatstone bridge for an instant by causing the commutator, D, to play. If everything is in order, the index does not budge during this maneuver. The commutator, C, permits of interposing a pair of receivers in the circuit of the line of the subscriber. As for the commutator, B_1, that serves for connecting the Wheatstone bridge with a flexible double conduc-

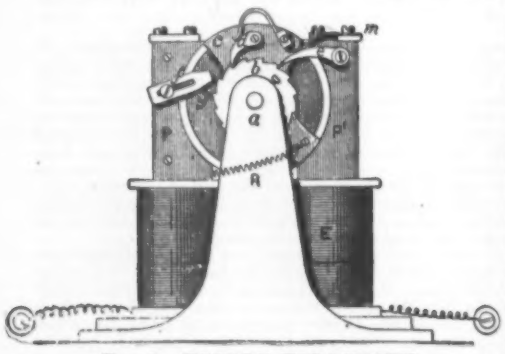


FIG. 5.—NEEDLE TELEGRAPH.

tor cord ending in a springjack. By means of the latter, any one of the cables ending at the switchboard is connected with the bridge, and all the local measurements that may seem necessary are easily made.

Let us say, too, a few words concerning the needle telegraphs (Fig. 5) that are used by the theatrophone company and the mechanism of which is both very simple and very ingenious. Upon an axis, a, which carries the needle, is keyed a toothed wheel, b, having a number of teeth equal to that of the divisions of the dial upon which the needle moves. Alongside of this toothed wheel, and mounted loosely upon the same axis with it, there is a soft iron armature, c, which revolves freely, with a very feeble play, between the polar pieces, P P' (hollowed out in semicircular form) of an electromagnet, E. A spiral spring, R, keeps the armature pressed against the fixed contact, m, and brings it back to the position shown in the figure as soon as it is left to itself.

When a current is made to pass into the electromagnet, E, the armature, C, owing to the initial keying, displaces itself in a direction opposite that of the hands of a watch, so as to embrace as large a number as possible of lines of force of the magnetic field created between the polar pieces, P and P'. In this motion it carries along with it, through the intermedium of the click, d, the toothed wheel, b, and consequently the needle keyed upon the same axis. The amplitude of the angular displacement, which thus affects the entire system, is regulated by the stop, f, which arrests the armature and which, at the same time, chocks the click, d.—Revue Industrielle.

ELECTRIC DISCHARGE THROUGH GASES.*

By Prof. J. J. THOMSON, F.R.S.

ONE of the most important and interesting branches of physical science is that which deals with the connection between electrical and chemical effects.

The investigations on electrolysis made within these walls by Davy and Faraday proved that the important class of electrical phenomena associated with the passage of electricity through liquids are connected in the closest way with chemical action. They proved that no electricity will pass through most liquids unless chemical action occurs, and that for each unit of electricity which passes through the liquid there is a definite amount of chemical decomposition.

This case, though it is one where the laws are most accurately known, is but one among many electrical phenomena which are inseparable from chemical action.

So many instances of this kind have been discovered that we may perhaps venture to hope that we are not far from the time when it will be universally recognized that many of the most fundamental questions in chemistry and electricity are but different aspects of one and the same phenomenon.

Anything which throws light on the connection between electricity and matter, interesting as it is on its own account, acquires additional interest when regarded as elucidating the connection between chemical and electrical effects, and no phenomena seem more suitable for this purpose than those which are

FIG. 1

the subject of the discourse this evening—the discharge of electricity through gases. For in gases we have matter in the state in which its properties have been most carefully studied, while the investigation of the electrical effects is facilitated by the visibility of the discharge, affording us ocular, and not merely circumstantial, evidence of what is taking place.

The points to which I wish to refer particularly this evening are, first, some phenomena connected with the passage of electricity from the gas to the electrode or from the electrode to the gas; and secondly, some of the properties of the discharge when its course lies entirely in the gas.

By taking a long discharge tube, say one fifty feet long, and observing the luminous discharge through a rotating mirror, we can trace the course of the luminosity due to a single discharge, say one due to once breaking the primary circuit of an induction coil; if we do so, we find that the luminosity follows the direction of the positive current through the tube. That is, the luminosity begins at the positive electrode, it then rushes down the tube with enormous velocity, but when it gets to the negative electrode it receives a check; it does not disappear at once in that electrode like a rabbit going down a hole, but lingers around the electrode some time before entering it. In consequence of this delay in the positive discharge in getting out of the gas, there is an accumulation of positive electricity in the neighborhood of the negative electrode until the potential fall at this electrode increases to about 200 or 300 volts.

The positive electricity which accompanies the discharge thus finds considerable difficulty in getting from the gas to the metal, though as I hope to show you later on, as long as it keeps in the gas, it meets with what we may, in consideration of the views sometimes enunciated on this subject, call a ridiculously small amount of resistance, its real difficulty is to get out of the gas.

Though this effect has long been known, it is so important that I will venture to show one or two experiments which illustrate it. The arrangement of the first experiment is shown in Fig. 1. The apparatus

* Lecture delivered at the Royal Institution.—From Nature.

consists of a main discharge tube, across which is fastened a diaphragm made of excessively thin platinum leaf; there is a side passage from the tube, leading from one side of the diaphragm to the other, this is connected to a barometer tube, and by raising the cistern containing the mercury I can stop up the passage by a pellet of mercury. We will first observe the discharge when the side passage is open; you see that the discharge, instead of passing across the thin piece of platinum leaf, takes the very much longer route round the side tube, so as to avoid crossing the metal. We will now raise the mercury cistern, and close the side tube by a pellet of mercury; the discharge now has no alternative but to cross the metal at some part of its course, and you see that the main portion of the discharge goes back into the main tube.

In the second experiment the metal diaphragm is replaced by a very thin plate of mica; when the side passage is opened the discharge goes round, but when

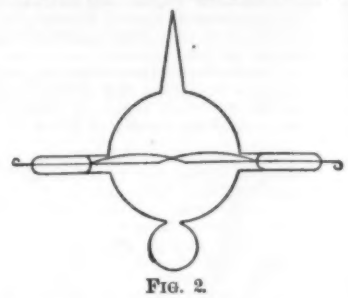


FIG. 2.

this is closed by a pellet of mercury the discharge prefers to go across the mica than through the mercury.

A second experiment which shows the same thing is the following: Two long electrodes are fused into a bulb, so that the tip of an electrode is a considerable distance from the place where it passes through the glass. We will now send an alternating discharge through the tube, and you will see, I think, that the discharge, instead of going straight across the short distance between the ends of the electrodes, goes from the tip of one electrode to the place where the other passes through the glass, thus staying as long as possible in the gas before passing into the metal. The appearance of the discharge shows that the positive electrode is at the end of the wire, the negative at the junction of the wire with the glass.

Another interesting example of the difficulty the discharge experiences in passing from gas to metal is the discovery made by Profs. Liveing and Dewar, that when the discharge passes through a gas containing a large quantity of metallic dust, the light from the discharge, when examined in the spectroscope, does not show any of the lines of the metal.

The difficulty which the positive electricity finds in passing from the gas to the electrode depends a great deal upon the nature of the gas, as well as upon that of the electrode; it is influenced by the position of the gas and the electrode relatively to one another in the electro-chemical series.

I have lately made a series of experiments on this point in the following way: An alternating discharge from a high tension transformer was made to pass between two electrodes fused into a bulb, which could be filled with the gases under examination. Another electrode connected to an electrometer passed into the bulb, and was arranged so that it could be moved about from one part of it to the other. When the electrodes were metal and the bulb was filled with the electro-negative gas oxygen, the electrode received a positive charge in whatever part of the bulb it was situated; if now the bulb was filled with hydrogen at atmospheric pressure, then in the regions remote from the arc the electrode received a positive charge, but in the immediate neighborhood of the arc itself it received a negative charge. When the pressure was reduced the region in which the charge was negative contracted, and finally at pressures about one-third of an atmosphere seemed to disappear, and the electrode got a slight positive charge in whatever position it was placed. If now, instead of using metallic electrodes we use well-oxidized copper ones, and repeat the experiment in hydrogen, working at a pressure when there was only positive electricity, when the electrodes were bright and polished, we find that with the oxidized electrodes every particle of positive electricity is taken out of the tube, and a negative charge is left. This negative charge remains until the copper oxide is completely reduced; when this occurs the negative charge disappears, and is replaced by positive. Thus, under the same conditions as to the nature of the gas and the pressure, the bright copper electrodes leave a positive charge in the gas, while the oxidized ones leave a negative charge.

The most probable explanation of these results seems to me to be the view that the communication of electricity from gas to the electrode, or from the electrode to gas, is facilitated by the temporary formation of something of the nature of a chemical compound between the gas and the metal. In all such compounds the metal is the electro-positive element, and has the positive charge, the gas being the electro-negative and carrying the negative charge. Now consider the case when the negative charge is on the gas and the positive charge on the metal; then the gas and metal have got the charges proper to them in any compound they may form, and are thus in a fit state to combine, or according to this view, allow the negative electricity to pass from the gas to the copper. But, now suppose the gas was positively electrified, the gas and the metal have now opposite charges to those proper to them in a compound, and before the union of gas and metal in this state could result in anything but a most unstable compound, an additional process must be gone through—i. e., the charges on the gas and metal must be interchanged. Thus the conditions for the combination of the gas and metal are more complex when the gas is positively electrified than when it is negatively electrified, and thus, on the view that the communication of electricity between the gas and the metal involves a sort of chemical combination, we see that the negative

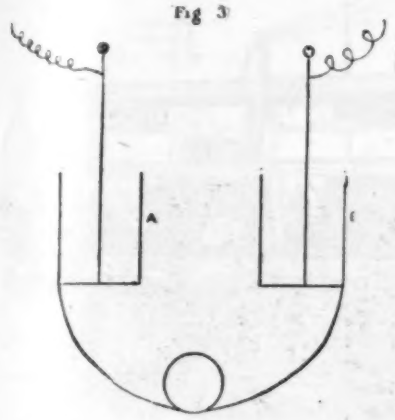
electricity will escape more easily from the gas to the metal than the positive. Now consider the case when the gas was hydrogen, the electrodes oxidized copper; the hydrogen combines now not with the metal, but with the oxygen, forming water, in which hydrogen is the electro-positive element; thus, in this case, it is the positively charged hydrogen which is in the state best fitted for pairing. The consequence is the positive charge would be most readily removed from the gas and the negative left—exactly the opposite to that which occurred when the electrodes were bright. This reversal, as I stated before, is verified by experiment.

It have hitherto only spoken of the phenomena which accompany the passage of electricity from the electrode to the gas or from the gas to the electrode.

I shall now pass on to consider the properties of the discharge when it is entirely confined to the gas.

We may produce a discharge which, during the whole of its course, shall be confined to the gas in the way represented in the diagram.

Fig 3.



The two poles of a Wimshurst machine are connected to the insides of two jars, A and B, while the outsides of these jars are connected together by a metal wire wound so as to form a coil. The electricity from the Wimshurst machine charges up the jars, the difference of potential between the poles increases until a spark passes. The passage of the spark puts the insides of the two jars in connection, and the jars are discharged. The discharge of the jar, as was proved from the theory of electro-magnet action by Lord Kelvin more than forty years ago, and shortly afterward confirmed by the experiments of Feddersen, is an oscillatory one, producing currents surging backward and forward through the wires with extraordinary rapidity. The subject of these oscillatory currents is one which is tinged with melancholy. In the beginning of 1894 we lost Hertz, whose splendid work on these electrical oscillations is known to you all. The managers of this institution have marked their sense of the importance of this work by devoting a special lecture to this work alone, and they have entrusted that lecture to a most distinguished worker in the same field as Hertz. It would therefore be presumptuous on my part to refer in any detail to Hertz's work; but no physicist, and least of all one who is a member of Maxwell's university, could pass over in silence the death of Hertz.

When Hertz began his magnificent experiments on electric oscillations, there were many theories of electrical action. When he had finished them there was only one, Clerk Maxwell's.

Hertz's work was done with very much quicker vibrations than those produced by the apparatus now on the screen; this, however, gives rise to currents through the coil changing their direction some million times a second. If we place in the coil an exhausted bulb, the bulb in reality will be the secondary of an induction coil, and will be exposed to electro-motive forces tending to produce circular currents parallel to the plane of the coil.

I will now place a bulb inside this coil, and you see that a circular ring discharge passes through it, and this discharge passes entirely in the gas.

The gas in the bulb now in the coil is the vapor of silicon tetrachloride; it happens to be the bulb which gives a brighter ring than any others I possess.

If this ring discharge passes through air at different pressures, the color of the discharge changes very considerably. The first bulb I put in was at fairly high pressure, about one-tenth of millimeter or so. I will now put in another at a lower pressure, and then one at a still lower pressure. Mr. Newall, who has been working at the spectra of these discharges, finds that at the pressure in the first bulb the spectrum is due to nitrogen; at the second stage it is due to mercury vapor; the bulb was pumped by a mercury pump, so that there is in the bulb a certain quantity of mercury vapor.

The apple-green color in the more highly exhausted bulb is due to some compound of sulphur, which has got into the bulb from the sulphuric acid used to dry the gas. Mr. Newall finds that if the ordinary discharge from a coil between electrodes is taken in such a bulb, there is no trace of this sulphur spectrum. He has also found that when the bulb is at a pressure intermediate between what I may call the mercury and the sulphur stage, when the mercury and sulphur lines are both visible, these sets of lines come from different layers, the sulphur lines coming from a layer nearer the surface than the other.

If we take the discharge through a bulb containing oxygen, you will see that the ring discharge is succeeded by a bright glow; at first the color is somewhat opaque, but gradually gets more transparent and changes color. This gives a continuous spectrum crossed by a few bright lines. If we take the discharge through cyanogen, you see that the glow is even more persistent than the oxygen, though it is not so bright; all the gases which show this glow belong to the class of substances which polymerize—that is, whose molecules can combine with each other. I imagine that what takes place in bulbs filled with these substances is that the discharge produces a polymeric modification, and that this gradually returns to its original state, and while doing so gives out a phosphorescent light. It is in accordance with this that at a high temperature where ozone cannot exist a discharge through an oxygen bulb does not show any glow.

I said at the beginning of this discourse that gases were exceedingly good conductors of electricity. I will now endeavor to show an experiment which proves that statement. The apparatus which I shall use for this purpose is a slight modification of the one I have used for producing the ring discharge; the only difference is that in the wire connecting the two coatings of the jars there are two loops instead of one. In one of these loops an exhausted bulb is placed to serve as a kind of galvanometer; the brightness of the discharge is an indication of the strength of the current flowing round the coil. If I place a second conductor in the other loop, currents will be started in it, and part of

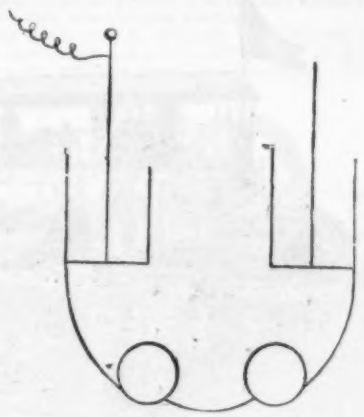


FIG. 4.

the energy of the discharge will be absorbed; this will leave less energy available for the bulb in the first, so that the discharge in this bulb will be dimmer. The effect produced on the discharge will depend upon the conductivity of the substance placed in the second loop.

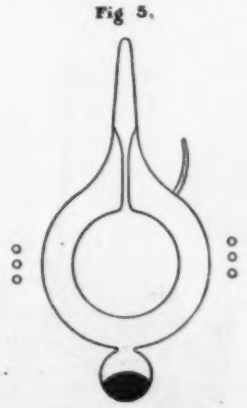
The effect is not directly proportional to the conductivity; in fact, a perfect conductor would not produce any diminution, nor would an absolute non-conductor; for a given period, and with apparatus of given dimensions, there is a certain conductivity which gives a maximum effect; this follows easily from the theory of induction of currents, but at this late period in the evening I will take a shorter course and prove it by an experiment.

I put a piece of brass in this loop, and you see it produces but a small effect upon the brightness of the discharge. Instead of brass I now insert a plumbago crucible, which, though a conductor, is not nearly so good a one as the brass, and you see the discharge in the indicating bulb is completely stopped.

I will now place in the second loop an exhausted bulb; you see it produces a decided diminution in the intensity of the discharge in the galvanometer bulb. I now replace the bulb by another of the same size containing dilute sulphuric acid; you see it does not produce nearly so large an effect as the exhausted bulb; this might be due, as we have seen, to the sulphuric acid being either too good or too bad a conductor. I can show that it is the latter by putting a bulb in filled with a stronger solution, which has a higher conductivity than the weak solution; if the smallness of the effect produced by the weak acid were due to its being a better conductor than the gas, then increasing the conductivity would still further diminish the effect of the acid; you see, on the contrary, that the strong acid produces a distinctly greater effect than the weak; hence the rarefied gas in the bulb is a better conductor even than the strong electrolyte.

Let us consider for a moment the molecular conductivities of the two substances, the rarefied gas and the electrolyte. The pressure of the gas is about $\frac{1}{100}$ of a millimeter, while in the electrolyte there are sufficient molecules of the acid to produce, if they were in the gaseous state, a pressure of more than 100 atmo-

Fig 5.



spheres; thus the conductivity of the gas estimated per molecule is about ten million times that of the acid; this is greater than the molecular conductivity of even the best conducting metals.

If the pressure of the gas is diminished below a certain point, the conductivity begins to diminish. I have here an experiment which I hope will show this. The apparatus (Fig. 5) consists of two bulbs, one outside the other; the inner bulb contains air at a low pressure, while the space between the two bulbs is a very high vacuum containing practically nothing but a little mercury and its vapor. The amount of mercury vapor in this space is, at the temperature of the room, exceedingly small, but as the apparatus is heated the vapor pressure increases, and we are thus able to produce a fairly wide range of pressure in the space between the bulbs. The outer sphere is surrounded by the coil connecting the outer coatings of the two Leyden jars. When the space between the bulbs is a conductor, the alternating currents circulating in the coil will induce in this conductor currents whose inductive effect is opposite to that of the currents in the coil; and in this case this layer will screen off from the inner bulb the electromotive force due to the alternating currents in the coil. If, on the other hand, the space between the bulbs is a non-conductor, the inner bulb will be exposed to the full effect of these forces. We now try the experiment; you observe that when the mercury is cold, and consequently the pressure in the space between the bulbs very low,

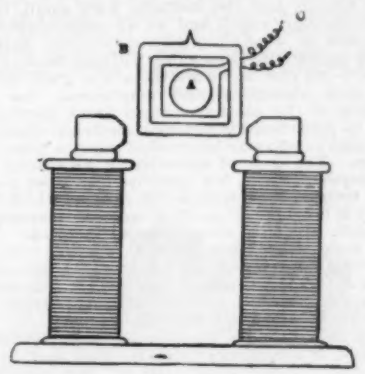


FIG. 6.

a bright discharge passes through the inner bulb, while the space between the bulbs remains quite dark; when we heat the mercury so as to increase the pressure of its vapor, a bright discharge passes through the outer layer, while the inner bulb is quite dark; the outer layer is now a conductor, and by its action screens off from the inner bulb the induction of the coil.

The last experiment I have to show is one on the effect produced by a magnetic field on the discharge. When the discharge has to flow across the lines of magnetic force, the pressure of the magnetic field retards the discharge; when, however, the discharge flows along the lines of magnetic force, the discharge is helped by the magnetic field. This is shown in the following experiment. A is a bulb; B a square tube, one side of which is placed between the poles of an electromagnet; the coil, C, which connects the outside coatings of the jars, can be adjusted so that when the magnet is "off," the discharge passes through the bulb but not round the square tube; when, however, the magnet is "on," the discharge passes in the square tube but not in the bulb. In the square tube the discharge passes along the lines of magnetic force and is helped; in the bulb it passes across them and is retarded.

[FROM ELECTRICAL INDUSTRIES.]

ELECTRICITY FOR MECHANICS.

By GEORGE CUTTER.

As a mechanic, I feel like conferring with fellow mechanics on the interesting theme of electricity. Do not consider electricity a subtile, mysterious force differing in all its laws from those of the mechanical forces All forces are subject to similar laws, and we will all understand electricity much more clearly by considering it the same as we do the mechanical forces which we are using every day. A furnace man well appreciates the three factors of quantity, pressure, and time in laying out his work, and he knows that he has resistance to overcome in distributing hot air through a set of pipes. The peculiar problems of his trade are no simpler than those of electricity, and they are very similar. The steam fitter also used the same three factors in his trade, and would not put up a half-inch pipe to carry steam 50 lb. pressure, 200 feet to a 100 horse power engine any more than an electrician would put up a No. 14 wire to carry electricity at 50 volts pressure 200 feet to 1,000 incandescent lamps. The reasons for certain size pipe are similar to those for certain size wire.

Get into the habit of studying the distribution of electricity as you do the distribution of steam, and all the problems become easy to understand. Gas, water, etc., are distributed for all sorts of purposes, and the laws governing them are similar to those governing electricity. Each trade has, of course, some elements which have to be considered that are neglected in others, but the main laws are common to all, and do not require different interpretations, except possibly in degree. Air, steam, gas, water, etc., are all treated in pounds pressure. Electricity is treated in volts pressure, but the volt is simply a certain definite part of a pound pressure, only a very small part. This is done because electricity is handled so differently as to require a different unit. The pound pressure could be used, but its use would be as awkward as the ton would be for diamonds. As a carat is a certain part of a ton, so a volt is a certain part of a pound pressure. The reason for different units becomes plainer when we think of the units of quantity. Cubic yards for air, cubic feet for gas, gallons for water, etc. Applied electricity being modern, new units were required, and scientific societies have adopted same. The problems before them were the adoption of the most convenient units and naming them. The names selected were those of eminent electricians who had helped advance our science to a state where it could become practically useful. As we always consider a resistance to passing air, gas, steam, or water through pipes, so we do in passing electricity through a wire. The unit of this resistance is the ohm, named after the great

mathematician who enunciated a simple expression of the relations between quantity, pressure, and resistance, known as Ohm's law.

Momentum and inertia exert quite an influence in water distribution, but not very much in air, steam, and gas. The reason is obvious; water distribution means the movement of a liquid that cannot be reduced by pressure, but air, steam and gas can be reduced by pressure, and they expand very quickly when the pressure is reduced, this rendering them very elastic. The effects of momentum and inertia are used up in the elasticity of the gas instead of producing outside effects, which have to be arranged for, as in water distribution. Momentum and inertia exert quite an influence in distributions of electricity and magnetism.

This is also easily understood by comparison. Water distribution means the forward movement of the mass of water, but electrical distribution means the forward movement of a peculiar mode of motion imparted to the molecules of the conductors. The molecules are very minute, and the motions very small, but they are exceedingly rapid, and we all appreciate the force of inertia in a small body moving very rapidly. A tallow candle shot from a rifle will pass cleanly through a board—all due to its inertia at the great speed. So also with electricity and magnetism, the extreme rapidity of the motions causes great inertia, which must be considered in practical electrical distributions. And neglect of same has caused many a plant to lose money. The unit of quantity in electricity is called the ampere, that is, the quantity unit most commonly used, because it represents the rate at which the electricity is flowing. The other unit of quantity is the coulomb, which is simply ampere-seconds. I might say a horse passed my house at a three minute gait, but could not tell how far he traveled without giving the time. A three-minute gate for six minutes makes two miles traveled. A one ampere current for one second makes one coulomb of electricity.

This unit is misleading, and never should have been adopted, as it implies something that can be kept in

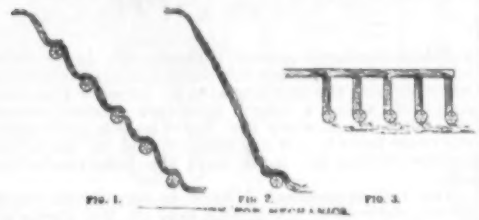


Fig. 1. Fig. 2. Fig. 3.

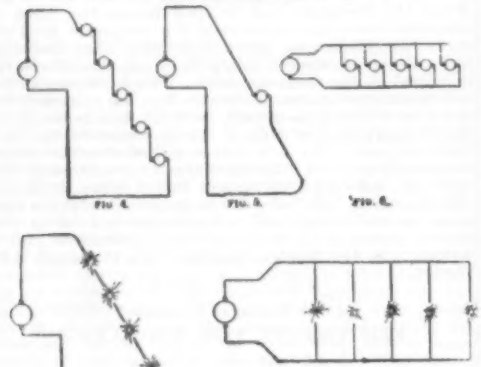


Fig. 4. Fig. 5. Fig. 6.

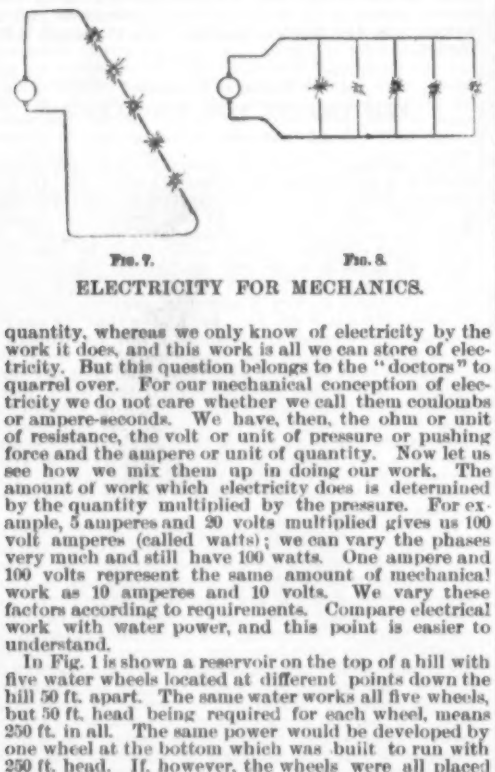


Fig. 7. Fig. 8.

ELECTRICITY FOR MECHANICS.

quantity, whereas we only know of electricity by the work it does, and this work is all we can store of electricity. But this question belongs to the "doctors" to quarrel over. For our mechanical conception of electricity we do not care whether we call them coulombs or ampere-seconds. We have, then, the ohm or unit of resistance, the volt or unit of pressure or pushing force and the ampere or unit of quantity. Now let us see how we mix them up in doing our work. The amount of work which electricity does is determined by the quantity multiplied by the pressure. For example, 5 amperes and 20 volts multiplied gives us 100 volt amperes (called watts); we can vary the phases very much and still have 100 watts. One ampere and 100 volts represent the same amount of mechanical work as 10 amperes and 10 volts. We vary these factors according to requirements. Compare electrical work with water power, and this point is easier to understand.

In Fig. 1 is shown a reservoir on the top of a hill with five water wheels located at different points down the hill 50 ft. apart. The same water works all five wheels, but 50 ft. head being required for each wheel, means 250 ft. in all. The same power would be developed by one wheel at the bottom which was built to run with 250 ft. head. If, however, the wheels were all placed on a level and fed from a canal connecting with the reservoir and 50 ft. head, as before, we would require five times as much water for the same power.

If our reservoir is replaced by a dynamo and our water wheel by an electric motor, the analogy will be plain. If each motor uses 50 volts (instead of feet head), and one is placed after the other in series, the same electricity would work all motors, but the dynamo must furnish five times 50 volts or 250 volts. With this same dynamo giving 250 volts, one motor built for the whole 250 volts would give the same power as the other five added together. If, however, the dynamo only gave 50 volts but could furnish more quantity, then we would need five times the quantity to get the same power as before. In one case, Fig. 4, the same quantity with five times the pressure, and the other case, Fig. 6, the same pressure but five times the quantity.

Carry the same idea to electric lamps. In Fig. 7 the dynamo furnishes electricity for five lamps of 50 volts each, the quantity being 10 amperes, five times 50 volts equals 250 volts, and this multiplied by 10 amperes gives 2,500 volt-amperes (called watts). Where the dynamo only gives 50 volts, however, as in Fig. 8, then five times the quantity will be required for the five lamps, five times 10 amperes equal 50 amperes, 50 volts multiplied by 50 amperes equal 2,500 watts, viz., same power as before.

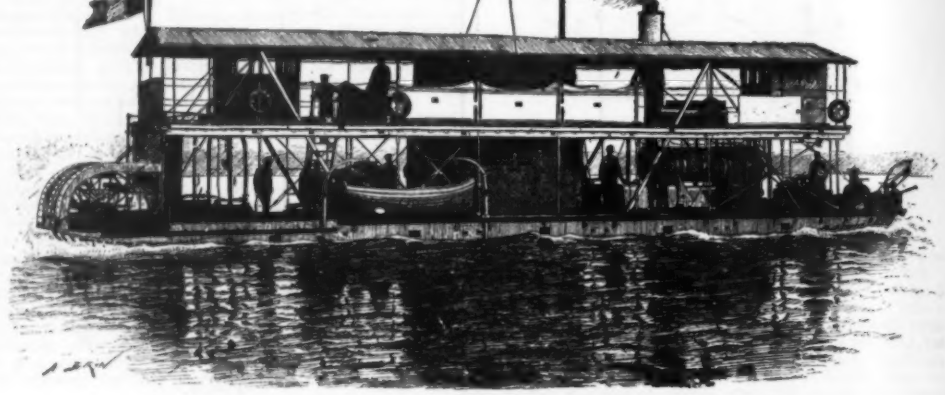
All problems in electricity seem plainer by comparison with the forces we are using every day. The momentum and inertia mentioned are chiefly felt in alternating current distributions, and are called retardation, hysteresis, resonance, etc., but they are all easily understood by comparison with the coarser manifestation of inertia.

THE LIGHT DRAUGHT FRENCH GUNBOAT PRECIEUSE.

The construction of the river flotilla for use in the Madagascar expedition is being pushed forward with great rapidity. This flotilla is composed of eight steam gunboats, four gunboats which are to be towed, forty-two flat boats and four pontoon boats. Already several of the boats are ready to be packed on the steamer which will carry them to Majurga. The first of these boats which was launched was the gunboat Precieuse, which we illustrate. This boat is 82 feet long, the breadth is 18 feet and the draught is only 15·7 inches. The engine has 50 indicated horse power and actuates a stern wheel. A speed of 6½ knots per hour has been obtained with this boat. It is armed with two rapid guns of a caliber of 37 millimeters (1·75 inches). The superstructure is very light, consisting only of light deck houses to protect the combatants and a shelter for the commander. The rapidity with which the Precieuse has been constructed reflects great credit upon the Société Anonyme des Forges et Chantiers de la Mediterranée at La Seyne. It was begun December 10, 1894, and finished just a month later. The official trial took place January 17. The other vessels which are being built by the same concern are being rapidly completed and by March 15 it is expected that they will all be delivered to the navy department. For our engraving and the foregoing particulars we are indebted to L'Illustration.

THE ELBE DISASTER.

The North German Lloyd steamship Elbe, bound from Bremen for New York, was sunk in a collision with the British steamer Crathie fifty miles off Lowestoft, England, on the morning of January 30. The stem of the steamer Crathie struck the Elbe about one hundred and fifty feet forward of the rudder, or just abaft the engine room. The engines were not damaged by the collision, but the water soon poured in, and although the steam pumps were put to work, it became apparent that the vessel was doomed; the fires were extinguished by the water and the engines and pumps stopped working. As the Crathie backed off and drew her stem out of the great cut made in the side of the Elbe, the latter careened over to port and began to settle by the stern. Although three boats were lowered on the port side, all but one were lost. By this time the list of the ship was so great that the starboard boats could not be lowered, and soon after the ship went down by the stern, and out of the three hundred and fifty-four persons only twenty were saved.



THE LIGHT DRAUGHT FRENCH GUNBOAT PRECIEUSE.

After the accident the Crathie steamed to Maassluis (Holland) in the condition shown in our engraving, the bow being completely smashed. For our engraving we are indebted to L'Illustration.

ROTARY BOTTLING MACHINE.

The apparatus represented in the accompanying engraving, and which has been devised by Mr. Borel, of the Pernod establishment, at Pontarlier, permits of drawing a liquid from a cask, in order to bottle it, with remarkable celerity, and with the aid of but very few operatives. The apparatus is movable upon an axis or vertical pivot, as if it were a question of a reel whose arms were replaced by siphons emerging like spokes from a central reservoir for receiving the bottles to be filled. A slight pressure of the hand suffices to cause a revolution of the apparatus, whose siphons present themselves in succession to the comfortably seated operative. The height of filling is regulated by the position of a float that automatically actuates a cut-off adjusted upon the cover of the receiver, without, however, participating in its rotary motion, since it serves to connect the apparatus with the cask or reservoir that is drawn from.

The sensitiveness of the parts assures a constant level of the liquid in the receiver placed vertically. As a consequence of the theory of communicating vessels, the flow ceases in the bottles filled to this level, without ever exceeding it, whatever be their capacity, suspended by the neck, as they are, from the notched ring. The removal of a filled bottle suffices to put the siphon at rest upon its cut-off seat, while the substitution of an empty one sets it in operation again, and so on, with discontinuity. As the filling of the bottles is effected in less than one revolution, the exchange

THE ELBE DISASTER—THE BOWS OF THE CRATHIE.

can be made at the rate of from 15 to 20 per minute. The full bottles interposed upon the lower disk reach the two bottlers automatically and are removed by them as they pass.

In order to explain the operation of the apparatus, we shall have recourse to Fig. 2, which gives a vertical section passing through its axis and a plan view. The larger diameter of the apparatus is 36 inches and its total height is 32. It consists: (1) of a cast iron foot, A, with a steel pivot; (2) of a disk, B, with a grating, both of tinned copper, for the reception of the filled bottles; (3) of a copper receiver, C, tin plated internally and provided at its circumference with a bronze ring, D, containing twelve notches arranged for the reception of as many bottles by the neck; (4) of 12 jointed siphons, E, arranged radiatingly, and resting upon as many cut-off seats, F, in the interior of the receiver, through a play of counterpoises, G, in the form of balls; and (5) of a receiver cover with a bronze seat, H, for the automatic cut-off admission cock controlled by a cylindrical float regulatable at will.

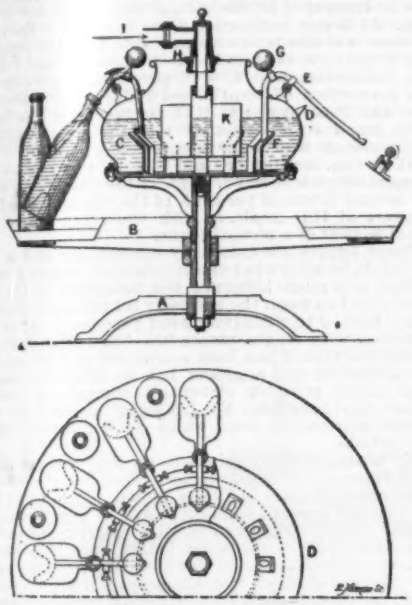


FIG. 2.—VERTICAL SECTION AND PLAN VIEW.

The setting in operation consists in connecting the apparatus with the cask by means of a rubber tube, I, and then regulating the height of the float, K, approximately. Such height can be determined after the 12 siphons have been primed in succession. It suffices to present the empty bottles to the siphons by giving the receiver a slight rotary motion for each of them. When the twelfth is placed, the first have been filled and are consequently ready to be exchanged for empty ones, which are brought to the vicinity of the apparatus in crates. On another hand, the full bottles interposed upon the disk, B, participate in the rotary motion, and as we have said, present themselves to the bottlers who remove them as they come to hand.

The normal output of an apparatus is from 1,000 to 1,200 bottles an hour. The first apparatus, which was constructed in 1883, has up to the present served for the filling of more than thirty million bottles, without necessitating any other repair than the replacing of a set of siphons. Its installation has permitted of quintupling the production on premises of a limited area and that had become inadequate. Fig. 1 gives a view of the arrangement of the apparatus in operation. The installation is rendered complete by a mechanical corking, after which the bottles pass to a special table in order to be labeled and be capped with tin foil. Two small carriages with rubber wheels receive the finished bottles at the end of this table, whence they are taken to be placed in piles, in order to give them time to dry before being packed.—La Nature.

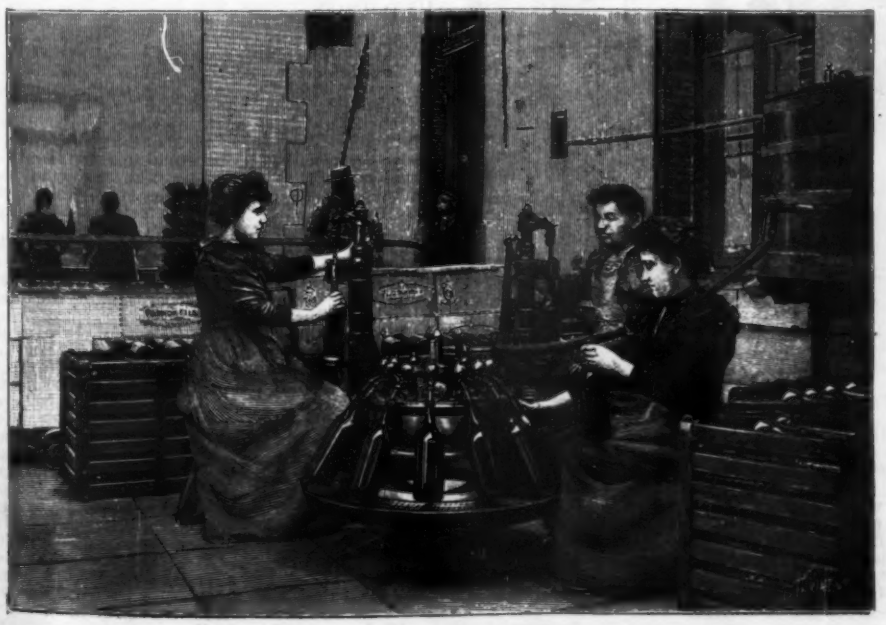


FIG. 1.—BOREL'S BOTTLING MACHINE.

THE LEBLANC'S COMPOUND SUGAR MILL.

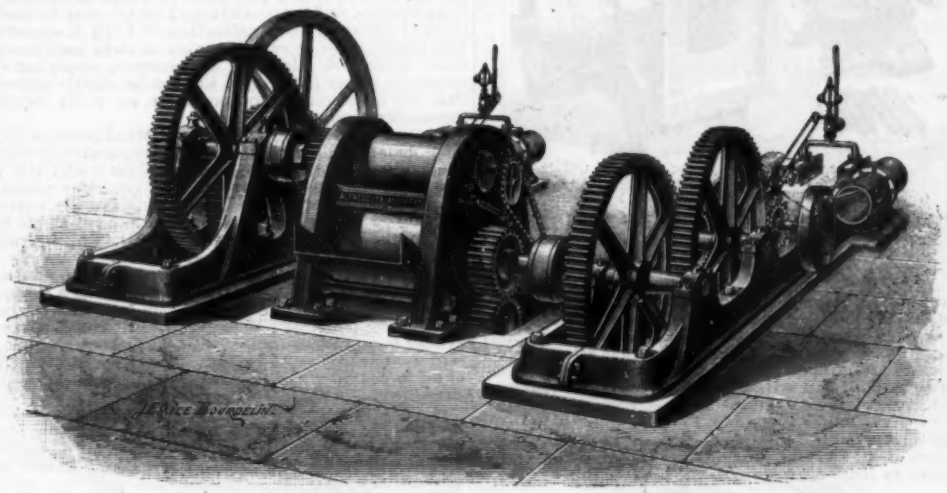
SUGAR cane planters have recently come to the conclusion, says the Engineer, that if their plantations are to pay they must obtain a high percentage of saccharine out of their canes, and they recognize that to effect this, mills of the most efficient type are absolutely necessary. But, even with a powerful mill of the usual three-roller type, it is found that the megass delivered contains so much juice that a second—even sometimes a third—crushing yields a quantity sufficient to more than pay for the additional plant and extra expense. When a second mill is arranged to recrush the megass from the first mill, an intermediate carrier is required to take away the megass from the first and deliver it to the second mill; during transit from the first to the second mill the megass is exposed to a certain extent, and acidity possibly set up; but a more important matter is that the shaking of the megass during transit causes it to be fed into the recrushing mill in irregular masses, so that a regular and even feed is an impossibility, and the extraction therefore suffers to a considerable extent.

To avoid these evils M. Leblanc has invented a mill which, it is claimed, has all the advantages of the two crushing mills without their disadvantages. The arrangement of his mill may readily be seen by referring to the illustrations, and it will not be necessary to do more than touch upon the principal points in the invention. In the first place, it may be said that although there are five rollers in the mill, there are really only four crushing rollers, the fifth being simply a feeding roller to the first crushing pair of rollers.

The canes are fed into the feed table A and pass between the feeding roller B and the first crushing roller C, and are then guided between the first pair of rollers C and D by the guide or turner E. The partly crushed megass is delivered by these rollers into the chamber or box F, which conducts it to and delivers it between the second crushing rollers G and H. As it is passed through these latter, it is delivered by means of a simple arrangement of scrapers into the delivery table J. The chamber F is arranged with perforated sides, so constructed that any liquor carried along with the megass may pass away readily. The sides are also set at a slight angle with one another, in order that the megass may more readily pass along. It is evident that by means of this box or chamber the megass is delivered into the second pair of rollers in a solid and compact mass, and a regular and even feed between the second crushing rollers is thereby insured. The sides of the chamber can readily be adapted to steaming the megass before recrushing, if desired, and they are also so arranged that they can be set closer together or further apart as required. It will be seen that the canes and megass are passed into the first and second pairs of rollers respectively in a vertical direction, thus permitting of the ready escape by gravitation of the liquor expressed.

A special feature of M. Leblanc's mill is that each pair of rollers is driven by a separate and independent engine and gearing, so that the speed of each pair of rollers may be varied at desire, and independently of that of the other pair. This enables the recrushing rolls to be run at a speed suited to the quantity of megass delivered by the first pair of rolls, so that although a limited quantity of canes may be fed into the mill, the feed between the last pair of rolls is compact and even, and the extraction is thereby kept up to the necessary high standard.

We may say that M. Leblanc has already one of his patent mills working, and at one of the trials conducted in the presence of fourteen independent witnesses, an extraction, we are informed, of rather more than 71 per cent. was obtained, and this was from canes which had been cut thirteen days previously. These results speak for themselves, for surely, if an extraction of 71 per cent. can be obtained from inferior canes, it is not too much to expect 75 per cent. with canes of an average quality. Below are the figures relating to two trials of one of these compound mills, the first of which was held at the Central Factory, "Constancia," in the island of Cuba, on July 5, 1890,



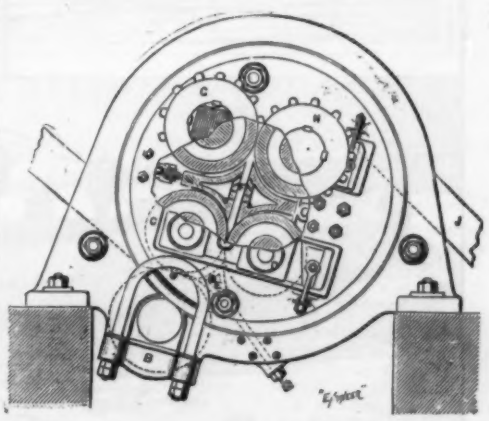
LEBLANC'S COMPOUND SUGAR MILL.

supplied by the analytical chemist to the Constancia works.

"I hereby certify that on the fifth day of July, one thousand eight hundred and ninety, there has been submitted for extraction by the new machine for grinding sugar cane, according to M. Alfred Leblanc's system: Eight hundred and eighty-three—883—kilos. of cane, producing five hundred and eighty-seven liters and seven centiliters—587·07 liters—of cane liquor, whose density being 1·0725 at a temperature of 15 deg Centigrade, is equal to six hundred and twenty-eight kilos. and five hundred and sixty grammes—628 kilos. 560 grammes—representing a yield of cane sugar amounting to seventy-one and five hundred and eighty-five thousandths per cent. on the weight of the cane. Analyzed by elimination, the said cane was shown to contain the following ingredients:

Vegetal water	71,690	
Crystallizable sugar	10,410	
Non-crystallizable sugar	0,480	=100,000
Residues on megass	16,549	
Ashes	0,871	

"Taking into consideration the poor condition of this cane, which had been cut thirteen days ago, and



having reference to the cane which has been worked up in February, March, April, 1890, it is admissible to assume that this mill will give a normal out-turn of 74 to 75 per cent.—seventy-four to seventy-five percentum—of cane liquor, on the weight of the cane, free from—vegetal—gores, straw and roots.

Mean analysis of the cane worked up in February, March, April, 1890.

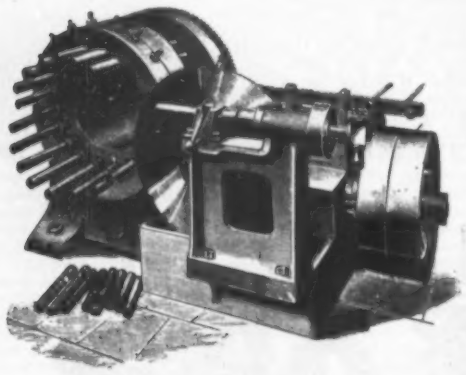
Vegetal water	70,870	
Crystallizable sugar	17.570	
Non-crystallizable sugar	0.920	100,000
Residue or megass	9,580	
Ashes	1,060	

Central Factory, Constancia, July 5, 1890.

"(Signed) PABLO FACIO."

CIRCULAR SAW FOR CUTTING BARS, ETC.

WE illustrate a circular saw of novel type, which has been specially designed for use in boiler shops and engine works, where quantities of screw stays, bars, etc., are frequently required to be cut to various lengths. The saw is driven by a gun metal worm wheel and pulleys, and by an ingenious arrangement the work is fed to it in such a way as to reduce to a minimum the time spent in fixing and releasing. Twenty holes of suitable diameter are pierced in the outer rim or margin of a revolving drum, and into these apertures are inserted the stays or bars to be cut. They are secured in position by an effective

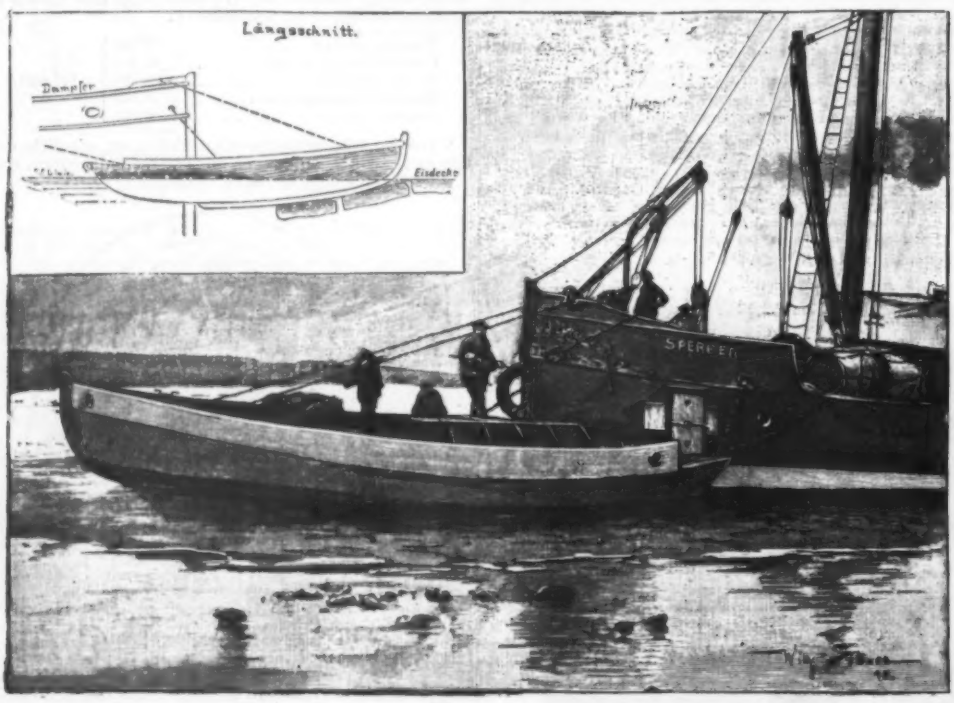


CIRCULAR SAW FOR CUTTING BARS, ETC.

clamping arrangement, and can be immediately withdrawn, after cutting, to make room for the insertion of another "length" of stay or bar, as the case may be. To remove any burr that may be left after cutting, a handy attachment is fitted to the machine, by which the attendant can grip the stay in a small vise, and with a revolving cup-shaped cutter, remove the burr and truly chamfer the end. The machine, it may be added, is capable of cutting stays or bars up to 2⅛ inches diameter. The inventor of the machine is Mr. Summers Hunter, Wallsend.—Marine Engineer.

A GERMAN ICE BREAKING MACHINE.

MR. WEEDERMANN, of Flensburg, has succeeded in constructing an apparatus by means of which any steamer can break through the ice without being injured. It is an oval, shallow boat that swims freely and whose keel gradually rises at the bow in a gentle curve. The rear part of the apparatus is divided into two parts by a wedge-shaped cut. The bow of the steamer to be protected should be placed in this cut, and then the apparatus is secured firmly to the steamer by means of chains or steel cables. If the boat is now started forward, the apparatus will be pushed against the ice and will break it, and there will be no danger of damage to the steamer. The tests made last



A GERMAN ICE BREAKER.

winter were very successful. The government vessel Sperber, when its bow was provided with this apparatus, traveled at the rate of three and one-half knots, breaking through ice that was six to seven inches thick, and was perfectly manageable. This test was made in the presence of a representative of the government and the results were satisfactory to all.—Illustrirte Zeitung.

WIND PRESSURES ON BUILDINGS.

IT has for some time past been recognized that certain time-honored formulas, much used for calculating the effect of wind pressures on surfaces—such as roofs of buildings—inclined at an angle to the direction of the air currents, are not to be depended upon, and that a larger margin of safety than was formerly considered necessary is advisable when using them. One excellent reason that pressures are in excess of those calculated is that the reduction of pressure on the leeward side has not been sufficiently allowed for, the action of induced currents not having been so well understood, or, at any rate, so generally recognized when these formulas were constructed as they are in the present day. So far as we are aware, Mr. Horatio Phillips, an experimenter whose work in this direction has not received the acknowledgment it deserves, was the first to draw attention to the rarefaction of the atmosphere on the leeward side of a hill or roof-like structure, and we well remember some years ago witnessing experiments of his which not only proved the fact but gave quantitative results. Since then other investigators have pursued the subject. The latest addition to our knowledge on this question has been supplied by a Swedish experimenter, Mr. R. Irminger, who has recorded the results of his investigations in the form of a paper, published in the Ingenioren, of Copenhagen, and a translation of which may be found in the Library of the Institution of Civil Engineers.* The experiments were made with models, and though some correction might be necessary in applying the results to larger planes, yet the results clearly indicate that the question of wind pressures on roofs requires reconsideration.

As is pointed out, experiments on wind pressure have been usually made by means of an apparatus in which the body subject to pressure revolves under the influence of the moving current. Mr. Irminger proceeds on the more exact method of causing the air current to impinge on the surface when stationary. This was the method formerly pursued by Mr. Phillips, who, however, obtained an induced current by means of steam jets, while Mr. Irminger has recourse to an opening in a tall chimney. In this was inserted a horizontal wooden tube 9 in. by 4½ in. in section. Experiments were made with inclined planes, prisms, spheres, cylinders, pyramids and cones. The planes were each represented by two thick iron sheets placed one-tenth of an inch apart, and their edges connected all round, thus forming a shallow closed box.

Holes were bored in both surfaces, and these could be plugged at will. The pivot on which the plane swung was a pipe leading to the interior of the box and having a pressure gage on the end. In this way any increase or reduction of pressure on either surface of the box-like plane could be ascertained.

A plane 4½ in. by 1½ in., and occupying the full width of the tube, was tried at various angles of inclination and with four velocities of air. When the plane was at an inclination of 5 deg. to the direction of the wind, the percentage of the total pressure which was produced on the leeward side of the plane was 100 at all velocities of wind tried, and the total wind pressure was 33 per cent. of what it would have been had the plane been normal to the air current. By "pressure on the leeward side of the plane" is meant the pressure on the leeward sheet of iron. This pressure would naturally be in the direction of the wind and would be caused by the reduction of atmospheric pressure on the opposite side, due to rarefaction. At an inclination of 10 deg. with an air velocity of 49·5 per second, the proportion of total pressure on the leeward side was 82 per cent., and at 31 ft. per second the pressure on the leeward side was 91 per cent. The proportion of total wind pressure at this angle, as compared to the same area of normal plane, was 45 per cent. At 40 deg. inclination of the plane, and with a velocity of 49·5 ft. per second, 65 per cent. of the total pressure was due to the leeward side; at 31 ft. per second it was 70 per cent.

The proportion of pressure as compared to the normal plane was 75 per cent. at this angle. At 90 deg. inclination of the plane, and 49·5 ft. per second of air current, the proportion of total pressure due to the leeward side was 56 per cent.; at 31 ft. it was 59 per cent., and at this angle the total pressure was equal to that which would have been sustained had the plane been vertical or normal to the current. We have, for the sake of brevity, selected only a few typical instances contained in Mr. Irminger's tables, and the figures as to the proportion of pressure as compared to normal planes are averages of a larger number of experiments than we quote.

The plane referred to, having its ends touching the sides of the box, may be considered as a plane of infinite length. Mr. Irminger tried a similar series of experiments with a plane 2 in. shorter—viz., 2½ in. by 1¼ in. At 5 deg. inclination the results were similar to those obtained with the larger plane at the same inclination, excepting that the proportion of total pressure as compared to the normal plane was but 12 per cent. At 10 deg. inclination also the whole of the total pressure was due to the leeward side, but the pressure was 26 per cent. of that due to a normal plane. At 40 deg. inclination and 49·5 ft. per second air current, the proportion of total pressure due to the leeward side was 78 per cent.; at 31 ft. per second it was 74 per cent., and the proportion of total pressure compared to the normal was 74 per cent.

At 90 deg. inclination and 49·5 ft. per second, the leeward effect was 48 per cent. of the whole; at 31 ft. per second it was 46 per cent. of the whole. The total pressure at this angle, as with the other plane, was equal to that of a normal plane.

These figures are extremely interesting; and it will, we think, be somewhat of a revelation to many persons to find how much influence the reduction on the leeward side has upon the necessity for strength in structures having to withstand wind pressures. It is not, however, with single planes (the box referred to was so shallow that it has been considered as a plane) that the architect and engineer has so much to deal, as with more complex structures comprising several planes, and here also Mr. Irminger supplies us with useful information, from which we can quote but a few details.

By a series of experiments on long prisms placed with their axes at right angles to the wind the effect of rarefaction on solid bodies is shown. The total pressure (57 per cent. of which was due to rarefaction) on a long plane of a given width s, placed normally to the wind, and of the same length as the prisms, is taken as a standard and is denoted by p. In a prism, the section of which was a square of side s, with the wind parallel to the side, the total resultant pressure in the direction of the wind was 0·95 p, the proportion due to rarefaction being 43 per cent. In a similar square turned so that the wind was parallel to the diagonal, the total resultant pressure was 0·79 p, with 76 per cent. rarefaction. With the section a circle of a diameter s, the total resultant pressure was 0·57 p, the percentage due to rarefaction being 72. In another series of experiments made with a sphere, it was found that only that part of the surface within 35 deg. of the diameter parallel to the wind's direction was subject to positive pressure from the wind, the remainder of the surface having its pressure reduced by rarefaction of the air.

Returning to the experiments with prisms, a rhombic cross section presenting an angle of 60 deg. to the wind, the length of side being s, showed a total resultant pressure in the direction of the wind 0·25 p, 82 per cent. of which was due to rarefaction; a section, an equilateral triangle, side s, gave 0·59 p total resultant pressure, with the wind parallel to the side and 0·42 p when the apex was presented to the wind; in the former case the proportion due to rarefaction being 42 per cent. and in the latter 86 per cent. When the prism was turned so that the base was presented to the wind, the total resultant pressure was 0·71 p, the percentage due to rarefaction being 37. It will be noticed here that in shapes with which the percentage due to reduction of pressure on the lee side is greatest, the total resistance is least, but in no case quoted does what may be called the rarefaction ratio fall below 37 per cent.

Further experiments were made with other forms. A cube with the wind striking it parallel to the edge showed a total resultant pressure in the direction of the wind of 0·80 of total pressure on a disk equal to the face, the percentage due to rarefaction being 22 per cent.; with the wind parallel to the diagonal of the face the pressure was 0·66. A cylinder of a height equal to its diameter received a pressure of 0·47 of that which would have been exerted on a square disk equal to a section through the axis, the rarefaction ratio being 50. A pyramid of square base with a side equal to the height gave, with the wind parallel to the side of the base, a pressure of 0·78 of that which would have been exerted upon a disk equal to a maximum section perpendicular to the wind; with the wind diagonal to the base the corresponding percentage was 55. In the former instance the rarefaction was 37 per cent. and in the latter 55 per cent.

Lastly, with a cone in which the height equaled the diameter of the base, the resultant pressure was 0·38 of that due to a disk equal to the maximum section perpendicular to the wind, 50 per cent. of the total pressure being due to rarefaction.

We have not space to follow up these results by practical applications. Experiments were made with models representing buildings of various forms. Generally it was found that the effect due to rarefaction on the lee side was quite as important a factor as the actual wind pressure on the windward side. To take an instance quoted of a roof of 45 deg. pitch, the wind blowing at right angles; the normal pressure sustained by the lee side of the roof, due to rarefaction, was over three times that due to wind pressure on the windward side, the resultant pressure being upward. On the windward side the pressure was found greatest near the lower edge, and, diminishing uniformly, became negative near the ridge. In the case of a model representing a gas holder with a segmental spherical roof, the pressure on the roof was entirely outward and the resultant nearly vertical.

We have not thought it necessary to describe the in-

* See also minutes of the proceedings Inst. C. E., vol. cxviii.

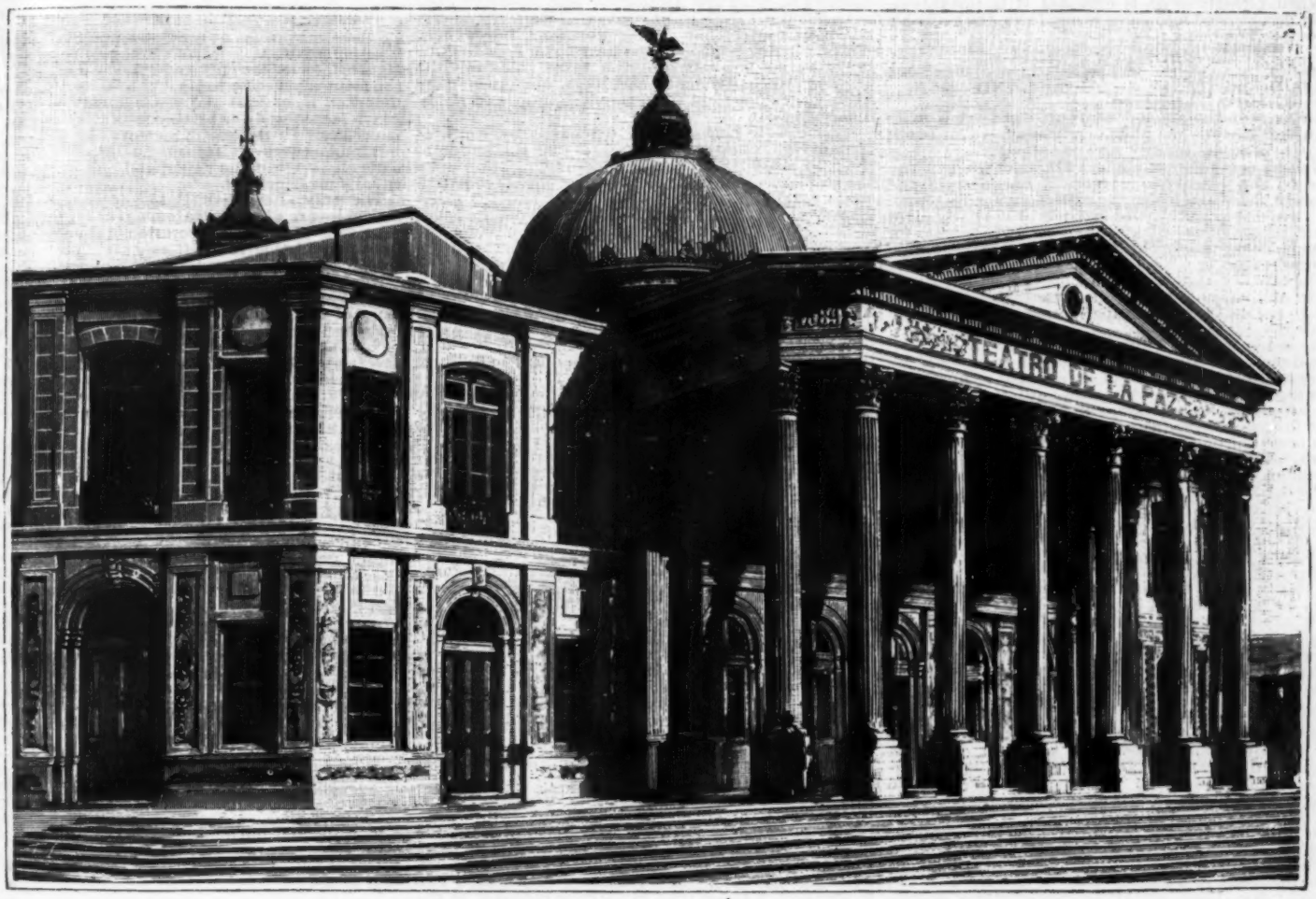
genious manner by which Mr. Irminger obtained his records of pressure, or to dwell upon other details of the manner in which the experiments were carried out. These, as well as much other interesting information, may be found in the original, and would well repay careful study.—The Builder.

THE NEW THEATER, SAN LUIS DE POTOSI, MEXICO.

On the sixteenth of September, 1889, the first stone of the beautiful edifice which we here represent was laid by Governor Gutierrez. It occupies the ground formerly covered by the convent of Carmen, and afterward by the penitentiary. There has been expended in this new work some $400,000, a large sum for such a city; but it may be said that Potosi now has the honor of possessing the best theater in Mexico, if not in Spanish America.

It is situated in the center of the city on the east side of the Plaza of Hidalgo and occupies a space of 4,500 square meters. The portico presents four columns of the Corinthian order, with capitals sculptured by workmen of the city, of very beautiful execution. Not less handsome is the atrium which these columns sustain. The vestibule, entered by five doors, is surmounted by a beautiful dome which rests upon sixteen columns. At the right and left of the vestibule two beautiful stairways arise, which lead up to spacious and elegant corridors, and from these the first series of boxes are entered. The decorations of the theater are most beautiful. There are a dozen paintings, allegorical, which represent music, painting, comedy, science, poetry, history, tragedy, architecture, etc. These were executed by Senor Sanchez. The general ornamentation is rich in details, luxurious and elegant. The edifice is lighted inside and outside with electric lights.

The architect was Don Jose Noriega, a distinguished Mexican architect.



THE NEW THEATER, SAN LUIS DE POTOSI, MEXICO.

[Continued from SUPPLEMENT, 1001, page 16001.]

EXPLOSIVES AND THEIR MODERN DEVELOPMENT.*

By Professor VIVIAN B. LEWES.

LECTURE II—CONTINUED.

THIS theory assumes that the vibrations are transmitted through and by the explosive, but Berthelot contends that the explosive substance does not detonate because it transmits the movement, but because it stops it, and transforms its mechanical force into calorific energy capable of suddenly raising the temperature of the substance to a degree at which its decomposition is effected, this in turn giving rise to the reproduction of a similar shock.

This vibratory movement Berthelot regards as a complex movement of a chemical and physical order when it is going on in the explosive, whereas it is purely physical when being transmitted through a substance like air whose nature is not changed by the wave, but on impact with the explosive body the wave is propagated by reason of a series of similar shocks incessantly reproduced in the explosive material, and which, as they continue, regenerate the energy throughout the wave and propagate the action with increasing velocity.

When however the shock has to be transmitted through air, the propagation is effected solely by reason of the last shock communicated to the air by the explosive, and which being no longer regenerated rapidly weakens by distance.

If Berthelot's theory be correct, the increase in velocity during detonation ought to admit of measurement by means of Nobel's chronoscope, and experiments made by Sir Frederick Abel showed that when 170 cylinders of compressed guncotton were placed end to end and detonated from one end of the series, the rate of detonation for the first six feet was 17,466 feet per second, and for the last six feet 17,738 feet per second, an observed increase which might well come within the limit of experimental error. It seems to me, however, that no matter how closely the cylinders were placed together, the break in continuity of the compressed cotton must tend to check the rapidity of propagation, and would therefore invalidate the results. The following analogies are suggested.

If a heavy ball be allowed to fall through the air from a height under the influence of gravity, the fall becomes more and more rapid as the distance from starting point increases, but if the ball be allowed to roll down a long flight of steps, the total vertical fall being equal to that of the previous case, each step breaking the fall, the increase in rapidity observed on the last step is but small.

The products formed during the explosion of guncotton vary so greatly with the conditions under which it is fired and the proportion of collodion cotton present, that any attempt to construct an equation must be misleading.

When guncotton is fired under ordinary atmospheric pressure, the products of combustion are found to be carbon dioxide, carbon monoxide, marsh gas, nitric acid, nitrogen, water vapor, and sometimes traces of cyanogen and hydrocyanic acid; but as the rapidity of explosion and the pressure increase, so the products become less complex. When detonated, the gaseous products of the decomposition are:

	Dry Guncotton.	Wet Guncotton.
Carbon dioxide	24·24	32·14
Carbon monoxide	40·50	27·12
Hydrogen	20·20	26·74
Nitrogen	14·86	14·00
Marsh gas	0·20	None.
	100·00	100·00

Estimations of the pressure developed by the detonation of guncotton differ greatly in value, Berthelot placing it as high as 24,000 atmospheres, or 160 tons on the square inch, while other authorities estimate it as not much more than half this pressure,

The experiments of Sir Frederick Abel show that the detonation of moist guncotton is rather quicker than of dry, while the work done by the same weight of cotton appears to be equal in either case. The presence, however, of water in the moist guncotton must use up a certain amount of the heat, but this will be accompanied by an increase in the volume of the gases owing to the extra hydrogen liberated. It has been proposed to soak the guncotton in paraffin instead of water in order to get over the trouble of evaporation, and this has been tried with fairly satisfactory results, but the addition of a hydrocarbon to a substance already containing too little oxygen for its complete combustion seems hardly advisable.

In 1847, Sobrero, while experimenting with glycerine, found that by treating this substance with strong nitric acid he obtained a compound which, on account of its exploding on a sudden rise of temperature, he called "pyro glycerine;" but its value as an explosive was not realized until 1863, when Alfred Nobel showed that by firing it by detonation an excessively powerful effect could be obtained.

Glycerine or glycerol—$C_3H_8O_3$—is a sweet, sirupy liquid, having a specific gravity of 1·269 and a boiling point of 290° C., at which temperature, however, it undergoes partial decomposition. It is soluble in water and in alcohol, but it is insoluble in ether. It is contained in the liquor left after the separation of soap in the manufacture of that article, being one of the products formed when oils or fats are acted upon by alkalies, and is obtained in still larger quantities during the manufacture of palmitic acid for candle making.

The vegetable fat, palm oil, which chiefly consists of palmitin, when acted upon by superheated steam, is broken up into palmitic acid and glycerine which can afterward be separated.

$$\underset{\text{Palmitin.}}{C_3H_5(C_{16}H_{31}O_2)_3} + \underset{\text{Steam.}}{3H_2O} = \underset{\text{Palmitic Acid.}}{3H(C_{16}H_{31}O_2)} + \underset{\text{Glycerine.}}{C_3H_5(HO)_3}$$

When acted upon by strong nitric acid, glycerine, like cellulose, is converted into a nitrate with simultaneous formation of water—

$$C_3H_5(HO)_3 + 3(HNO_3) = C_3H_5(NO_2)_3 + 3(H_2O)$$

In the manufacture of nitroglycerine, a mixture of 992 lb. of nitric acid, specific gravity 1·48, and 1,680 lb. of sulphuric acid, specific gravity 1·84, is thoroughly cooled and run into the mixing vat made of chemically pure lead, all the joints of which are autogenously melted together. The glycerine is then slowly and carefully added by means of an injector which regulates the rate of supply, while the whole charge is kept well agitated by blowing air through it, which not only thoroughly mixes the glycerine and the acids, but also prevents local heating. In this way 330 lb. of glycerine are mixed in with the acids, the process taking about an hour, and every precaution is taken to prevent the temperature rising above a limit of 22° C. (71·6° F.), the mixture being cooled by cold water, which is run through a coil of lead pipes inside the vat. If by any chance the temperature should rise to a higher limit, a valve in the bottom of the vessel can be opened and the whole charge run into a tank of water placed below it.

As soon as the nitrating is completed, the charge is run into a second lead tank or vat and allowed to stand for an hour, when the nitroglycerine separates and rises to the top of the mixed acids. When the separation is completed the acids are drawn off, and

* Four lectures recently delivered before the Society of Arts, London.—From the Journal of the Society.

the nitroglycerine is run off into lead vessels, where it is first washed with water and then with a solution of soda. The washing process is then repeated three times with hot water and soda, and after separating from the wash water is filtered through table salt and run into the store tanks.

Nitroglycerine so prepared is an oily colorless liquid, which has no odor and is soluble in water, although it rapidly dissolves in ether, benzol, wood spirit and hot alcohol, and from the solution so formed can again be precipitated on dilution with water.

It has a violent effect upon the system, acting in large doses like strychnine, while even traces produce vertigo; and, as it is absorbed through the skin, people working with it are frequently at first seriously affected, but after a time experience no ill effects and, it is said, present a more than usually healthy appearance. When cautiously heated to 100° C. it slowly evaporates, at 200° C. it burns, and detonates at 257° C. When a lighted match is applied to it, it burns quietly away, and, when the light is removed, the flame generally goes out; indeed, a lighted match may be extinguished by plunging it into nitroglycerine. It is, however, detonated by a sudden blow or by heating it to 257° C. Nitroglycerine becomes solid at 4° C., but so much depends upon the length of exposure to cold that this may happen at from + 8° C. to −11° C., and in this condition it is comparatively inert; hence it is necessary to thaw it before use, an operation attended with considerable risk. It is stated that exposure to the direct rays of the sun will convert it into a very unstable and explosive substance, and also that the presence of ozone will sometimes cause its spontaneous decomposition.

When nitroglycerine is exploded it is instantaneously decomposed into gaseous products, the probable decomposition being:

$$\underset{\text{Nitro-glycerine.}}{2(C_3H_5(NO_3)_3)} = \underset{\text{Carbon Dioxide.}}{6(CO_2)} + \underset{\text{Water.}}{5(H_2O)} + \underset{\text{Nitric Oxide.}}{NO} + \underset{\text{Nitrogen.}}{N_2}$$

showing that the amount of oxygen present is more than sufficient for complete combustion, which is not the case in any other explosive compound.

Nobel has found that about 1,200 times its own volume of gas, calculated at normal temperature and pressure, is generated by the explosion of nitroglycerine; while the heat evolved expands it to nearly eight times this volume. Its explosive force, volume for volume, being nearly thirteen times as great as gunpowder.

The rapidity of detonation of nitroglycerine is very great, and it is this which gives rise to the downward effects noticeable in all nitroglycerine or dynamite explosions.

Six cubic inches of nitroglycerine, when exploded, would yield about a cubic yard of gas, and would require approximately $\frac{1}{2500}$ of a second for conversion into the gaseous form. A square yard of surface carries an atmospheric pressure of, roughly, nine tons, so that the gaseous products would have to lift nine tons to a height of one yard in $\frac{1}{2500}$ of a second, and the earth, being rigid, is broken up by the recoil from this enormous strain.

For blasting purposes, nitroglycerine was at one time very extensively used; the fact of its being unaffected by moisture gave it a great advantage, while the rapidity of its explosion made it only necessary to prepare a bore hole, partly fill it with nitroglycerine, and then fill up the hole with water; the water forming just as good a tamping for the nitroglycerine when fired by detonation as if the hole had been plugged with wood or metal. The use of nitroglycerine for blasting purposes is, however, attended with several inconveniences, as being fluid it can only be used in downward bore holes, while its transport in the liquid form has given rise to many accidents; and, finally, the liquid state is not very suitable for detonation, as the fluid yields to the sudden blow, and is often scattered instead of being completely exploded, so reducing its power, and becoming a source of danger in subsequent operations. In order to avoid these drawbacks, Nobel made the nitroglycerine into certain plastic preparations by mixing it with various absorbent substances, and these mixtures, in many cases, have a higher explosive power than the nitroglycerine itself.

These nitroglycerine preparations to which Nobel gave the name of dynamite may be divided into two classes: first, those containing non-explosive absorbents; and, secondly, those with explosive absorbents. The majority of these will be considered under the heading of blasting explosives.

When first working in this direction, in 1866, Nobel used charcoal as an absorbent for nitroglycerine, and, encouraged by the success of his experiments, tried various other bodies which were capable of taking up and holding the nitroglycerine, and he came to the conclusion that the infusorial earth first found at Oberlohe, in Hanover, gave the most satisfactory results. This earth consisted of the remains of diatoms, and contained 95 per cent. of silica, which is so finely divided as to be free from any grit, and which, after having been heated to a moderate temperature, to remove moisture and organic matter, can be ground and sifted.

This substance is called kieselguhr, and is mixed with three times its weight of nitroglycerine, the mixture being made by hand kneading. It is sometimes squeezed by hand through the meshes of a coarse sieve, and sometimes is forced out of a metal tube by means of a peculiarly constructed Archimedean screw, the resulting mass being cut into lengths to form cartridges of the required size.

During the mixing of the substance 8 per cent. of sodic carbonate, baric sulphate, mica, talc, ocher, and ammonium carbonate are allowed to be added to it. This substance is generally known by the name of dynamite No. 1. In the large factory at Ardeer, the kieselguhr employed comes from Aberdeenshire, and is of considerable purity, containing 98 per cent. of silica, while in France a similar earth, called "randanite," is employed.

The finished dynamite is a semi-plastic substance of a reddish-brown color, containing 75 per cent. of nitroglycerine, and has a specific gravity, as made at Ardeer, of about 1·6. Under normal conditions dynamite can be set fire to by the application of a flame, and even when in considerable quantity can be burnt in this way without explosion; but, like nitroglycerine, if the temperature rises above a certain limit, the combustion increases in rapidity until the temperature of detonation is reached.

This phenomenon of the gradually increasing of combustion and consequent increase in temperature is found in all substances capable of undergoing detonation. If a mixture of nitric oxide and carbon bisulphide be inflamed in an open-mouthed jar, not more than eight or ten inches in height, it burns quietly, emitting a most brilliant light, but if a long cylinder be employed, the flash of light is seen in the upper part of the cylinder while the mixture in the lower portion violently explodes. The same phenomenon may be observed when burning mixtures of acetylene and air, as with a long tube or cylinder, containing a mixture of one volume of acetylene to three volumes of air, the combustion will often commence quietly with deposition of large volumes of carbon, but the flame rapidly becomes quicker and quicker until the last portion of the mixture detonates and generally breaks the vessel to pieces. In the case of guncotton also, it is well known that small quantities burn away perfectly quietly, but large masses will first burn in the ordinary way, then the temperature generated will often rise until the remainder explodes, and if a stick of guncotton were cast of considerable length, it would be found that, although it would burn quietly at first, the combustion, after a few inches had been consumed, would get so rapid that it would make a screaming sound, which would quickly get shriller and shriller until explosion resulted.

Dynamite, like nitroglycerine, freezes at a temperature of about 4° C. The frozen cartridges are less sensitive to shock and detonation, and therefore have to be thawed before use for blasting purposes, and it has been found that frozen dynamite burns very slowly, the first portion of the heat being used to thaw the substance before combustion takes place, but the burning frozen dynamite cartridges are much more likely to explode than when the dynamite is in its ordinary state.

Dynamite is not so easily detonated by shock as nitroglycerine, and Berthelot states that this is due to the inert mass present having a cushioning effect upon the mechanical force of the blow, the energy imparted being divided between the absorbent and the nitroglycerine, and for the same reason the dynamite is less crushing in its action than nitroglycerine, because the heat evolved in its detonation is shared between the products of explosion and the inert body present.

Experiments made by Sir Frederick Abel gave a velocity of propagation of detonation in dynamite as 20,000 feet per second, but the experiments having been made with half-inch cartridges placed end to end in a continuous train, 42 feet in length, the break in the homogeneous nature of the train may have introduced error into the result.

It is interesting to note that experiments made by General Abbott in submarine mining show that the intensity of the action of such dynamite containing 75 per cent. of nitroglycerine is greater than that of nitroglycerine itself, and a confirmation of this was found in the fact that Sir Frederick Abel found the rate of detonation of dynamite was much quicker than that of nitroglycerine; this, however, being to a certain extent due to the liquid particles of the latter having a tendency to escape from the blow of the detonator.

One of the great troubles with kieselguhr dynamite is that under certain conditions some of the nitroglycerine will exude from it, this being specially the case when wet or placed in water; and, in 1886, Mr. Walter Reid utilized the idea of making dynamite in which low burnt charcoal made from cork rich in hydrogen is used as the absorbing material instead of kieselguhr, and the absorbing power of this charcoal is so great that a dynamite can be made containing only 10 per cent. of the cork charcoal and 90 per cent. of the nitroglycerine, which is retained with such power by the absorbent nature of the inert material that it can be kept for years under water without losing its nitroglycerine, while the high percentage of explosive gives it a greater intensity of action than is the case with the kieselguhr dynamite.

This preparation is called carbodynamite, and the inventor claims that it can be made absolutely uninflammable by the incorporation with it of one-fourth its weight of water, which can easily be kneaded into it, and that in this state it can still be exploded by the use of a sufficiently powerful detonator.

[FROM NATURE.]

ARGON, THE NEW CONSTITUENT OF THE ATMOSPHERE.*

XVI. GENERAL CONCLUSIONS.

IT remains, finally, to discuss the probable nature of gas, or mixture of gases, which we have succeeded in separating from atmospheric air, and which we provisionally name argon.

The presence of argon in the atmosphere is proved by many lines of evidence. The high density of "atmospheric nitrogen," the lower density of nitrogen from chemical sources, and the uniformity in the density of samples of chemical nitrogen prepared from different compounds, lead to the conclusion that the cause of the anomaly is the presence of a heavy gas in air. If that gas possess the density 20 compared with hydrogen, "atmospheric" nitrogen should contain of it approximately 1 per cent. This is, in fact, found to be the case. Moreover, as nitrogen is removed from air by means of red hot magnesium, the density of the remaining gas rises proportionately to the concentration of the heavier constituent.

Second.—This gas has been concentrated in the atmosphere by diffusion. It is true that it has not been freed from oxygen and nitrogen by diffusion, but the process of diffusion increases, relatively to nitrogen, the amount of argon in that portion which does not pass through the porous walls. This has been proved by its increase in density.

Third.—As the solubility of argon in water is relatively high, it is to be expected that the density of the mixture of argon and nitrogen, pumped out of water along with oxygen, should, after the removal of the oxygen, be higher than that of "atmospheric" nitrogen. Experiment has shown that the density is considerably increased.

Fourth.—It is in the highest degree improbable that two processes, so different from each other, should manufacture the same product. The explanation is simple if it be granted that these processes merely eliminate nitrogen from an "atmospheric" mixture. Moreover, as argon is an element, or a mixture of elements, its manufacture would mean its separation from one of the substances employed. The gas which can be removed from red hot magnesium in a vacuum has been found to be wholly hydrogen. Nitrogen from chemical sources has been practically all absorbed by magnesium, and also when sparked in presence of oxygen; hence argon cannot have resulted from the decomposition of nitrogen. That it is not produced from oxygen is sufficiently borne out by its preparation by means of magnesium.

Other arguments could be adduced, but the above are sufficient to justify the conclusion that argon is present in the atmosphere.

The identity of the leading lines in the spectrum, the similar solubility and the similar density, appear to prove the identity of the argon prepared by both processes.

Argon is an element, or a mixture of elements, for Clausius has shown that if K be the energy of translatory motion of the molecules of a gas, and H their whole kinetic energy, then

$$\frac{K}{H} = \frac{3(C_p - C_v)}{2C_v}$$

C_p and C_v denoting as usual the specific heat at constant pressure and at constant volume respectively. Hence if, as for mercury vapor and for argon (§ XIV), the ratio of specific heats $C_p : C_v$ be 1⅔, it follows that K = H, or that the whole kinetic energy of the gas is accounted for by the translatory motion of its molecules. In the case of mercury the absence of interatomic energy is regarded as proof of the monatomic character of the vapor, and the conclusion holds equally good for agon.

The only alternative is to suppose that if argon molecules are di- or polyatomic, the atoms acquire no relative motion, even of rotation, a conclusion exceedingly improbable in itself and one postulating the sphericity of such complex groups of atoms.

Now a monatomic gas can be only an element, or a mixture of elements; and hence it follows that argon is not of a compound nature.

From Avogadro's law, the density of a gas is half its molecular weight; and as the density of argon is approximately 20, hence its molecular weight must be 40. But its molecule is identical with its atom; hence its atomic weight, or if it be a mixture, the mean of the atomic weights of that mixture, taken for the proportion in which they are present, must be 40.

There is evidence both for and against the hypothesis that argon is a mixture; for, owing to Mr. Crookes' observations of the dual character of its spectrum; against, because of Professor Olszewski's statement that it has a definite melting point, a definite boiling point, and a definite critical temperature and pressure; and because on compressing the gas in presence of its liquid, pressure remains sensibly constant until all gas has condensed to liquid. The latter experiments are the well known criteria of a pure substance; the former is not known with certainty to be characteristic of a mixture. The conclusions which follow are, however, so startling, that in our future experimental work we shall endeavor to decide the question by other means.

For the present, however, the balance of evidence seems to point to simplicity. We have therefore to discuss the relations to other elements of an element of atomic weight 40. We inclined for long to the view that argon was possibly one or more than one of the elements which might be expected to follow fluorine in the periodic classification of the elements—elements which should have an atomic weight between 19, that of fluorine, and 23, that of sodium. But this view is completely put out of court by the discovery of the monatomic nature of its molecules.

The series of elements possessing atomic weights near 40 are:

Chlorine	35·5
Potassium	39·1
Calcium	40·0
Scandium	44·0

There can be no doubt thir potassium, calcium, and scandium follow legitimately their predecessors in the vertical columns, lithium, beryllium, and boron, and that they are in almost certain relation with rubidium, strontium, and (but not so certainly) yttrium. If argon be a single element, then there is reason to doubt whether the periodic classification of the elements is complete; whether, in fact, elements may not exist which cannot be fitted among those of which it is composed. On the other hand, if argon be a mixture of two elements, they might find place in the eighth group, one after chlorine and one after bromine. Assuming 37 (the approximate mean between the atomic weights of chlorine and potassium) to be the atomic weight of the lighter element, and 40 the mean atomic weight found, and supposing that the second element has an atomic weight between those of bromine, 80, and rubidium, 85·5, viz., 82, the mixture should consist of 93·3 per cent. of the lighter and 6·7 per cent. of the heavier element. But it appears improbable that such a high percentage as 6·7 of a heavier element should have escaped detection during liquefaction.

If it be supposed that argon belongs to the eighth group, then its properties would fit fairly well with what might be anticipated. For the series, which contains

$$Si^{IV},\quad P,^{III\text{ and }V},\quad S^{II\text{ to }VI}_{2\text{ to }2},\quad \text{and } Cl^{I\text{ to }VII},$$

might be expected to end with an element of monatomic molecules, of no valency, i. e., incapable of forming a compound, or, if forming one, being an octad; and it would form a possible transition to potassium, with its monovalence, on the other hand. Such conceptions are, however, of a speculative nature; yet they may be perhaps excused, if they in any way lead to experi-

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* Abstract of a paper by Lord Rayleigh, Sec. R.S., and Prof. William Ramsay, F.R.S., read before the Royal Society, at a special meeting, on January 31.

Continued from SUPPLEMENT, No. 1001, page 16000.

ments which tend to throw more light on the anomalies of this curious element.

In conclusion, it need excite no astonishment that argon is so indifferent to reagents. For mercury, although a monatomic element, forms compounds which are by no means stable at a high temperature in the gaseous state; and attempts to produce compounds of argon may be likened to attempts to cause combination between mercury gas at 800° and other elements. As for the physical condition of argon, that of a gas, we possess no knowlege why carbon, with its low atomic weight, should be a solid, while nitrogen is a gas, except in so far as we ascribe molecular complexity to the former and comparative molecular simplicity to the latter. Argon, with its comparatively low density and its molecular simplicity, might well be expected to rank among the gases. And its inertness, which has suggested its name, sufficiently explains why it has not previously been discovered as a constituent of compound bodies.

We would suggest for this element, assuming provisionally that it is not a mixture, the symbol A.

We have to record our thanks to Messrs. Gordon, Kellas, and Matthews, who have materially assisted us in the prosecution of this research.

THE LIQUEFACTION AND SOLIDIFICATION OF ARGON.*

HAVING been furnished, by Prof. Ramsay's kindness, with a sample of the new gas argon, I have carried out experiments on its behavior at a low temperature and at high pressures in order to contribute, at least in part, to the knowledge of the properties of this interesting body.

Four series of experiments in all were carried out, two with the object of determining the critical temperature and pressure of argon, as well as measuring its vapor pressure at several other low temperatures, while two other series served to determine its boiling and freezing points under atmospheric pressure, as well as its density at its boiling point.

A detailed description of these experiments will be given in another place; I shall here give only a short description of the manner in which they were made.

For the first two experiments I made use of a Cailletet's apparatus. Its metallic manometer had been previously compared with the readings of a mercury manometer. As cooling agent I used liquid ethylene, boiling under diminished pressure. The glass tube of Cailletet's apparatus was so arranged that the portion immersed in the liquid ethylene had comparatively thin walls (not exceeding 1 mm.), so as to equalize the external and internal temperature as quickly as possible.

In both the other experiments the argon was contained in a burette, closed at both ends with glass stopcocks. By connecting the lower end of the burette with a mercury reservoir, the argon was transferred into a narrow glass tube fused at its lower end to the upper end of the burette, and in which the argon was liquefied and its volume in the liquid state measured. In these two series of experiments liquid oxygen, boiling under atmospheric or under diminished pressure, was employed as a cooling agent. I made use of a hydrogen thermometer in all these experiments to measure low temperatures.

DETERMINATION OF THE CRITICAL CONSTANTS OF ARGON.

As soon as the temperature of liquid ethylene had been lowered to —128·6°, the argon easily condensed to a colorless liquid under a pressure of 38 atmospheres. On slowly raising the temperature of the ethylene, the meniscus of the liquid argon became less and less distinct and finally vanished.

Seven determinations of the disappearance of the meniscus proved that the critical pressure was 50·6 atmospheres; but determinations of the critical temperature show slight differences.

The mean of the seven estimations of the critical temperature is —121°, and this may be taken as the critical temperature of argon.

The vapor pressures at ten temperatures from —128·6 to —139·1 were also determined.

DETERMINATION OF THE BOILING AND FREEZING POINTS.

Two hundred cubic centimeters of liquid oxygen, prepared in my large apparatus,† was poured into a glass vessel with quadruple walls, so as to isolate the liquid from external heat. After the liquid oxygen had been thus poured under atmospheric pressure, a great part of it evaporated, but there still remained about 70 c. c. boiling under atmospheric pressure. A calibrated tube, intended to receive the argon to be liquefied, and the hydrogen thermometer were immersed in the boiling oxygen. At this temperature (—182·7‡) on admitting argon, no appearance of liquefaction could be noticed, even when compressed by adding a quarter of an atmosphere pressure to that of the atmosphere. This shows that its boiling point lies below that of oxygen. But on diminishing the temperature of the liquid oxygen below —187°, the liquefaction of argon became manifest. When liquefaction had taken place, I carefully equalized the pressure of the argon with that of the atmosphere and regulated the temperature, so that the state of balance was maintained for a long time. This process gives the boiling point of argon under atmospheric pressure. Four experiments gave the numbers —186·7°, —180·8°, —187·0° and —137·3°. The mean is —186·9°, which I consider to be the boiling point under atmospheric pressure (740·5 mm.)

The quantity of argon used for these experiments, reduced to normal temperature and pressure, was 99·5 c. c.; the quantity of liquid corresponding to that volume of gas was approximately 0·114 c. c. Hence the density of argon at its boiling point may be taken as approximately 1·5. Two other determinations of the density of liquid argon, for which I employed still smaller quantities of the gas, yielded rather smaller numbers. Owing to the small amount of argon used for these experiments, the numbers given cannot lay claim to great exactness; yet they prove that the density of liquid argon at its boiling point (—187°) is much higher than that of oxygen, which I have found under similar conditions to be 1·124.

By lowering the temperature of the oxygen to —191° by slow exhaustion, the argon froze to a crystalline mass resembling ice; on further lowering temperature it became white and opaque. When the temperature was raised it melted. Four observations which I made to determine its melting point gave the numbers: —189·0°, —190·6°, —189·6° and —189·4°. The mean of these numbers is —189·6°, and this may be accepted as the melting point of argon.

In the following table I have given a comparison of physical constants, in which those of argon are compared with those of other so-called permanent gases. The data are from my previous work on the subject.

Name.	Critical temperature.	Critical pressure.	Boiling point.	Freezing point.	Freezing pressure.	Density of gas.	Density of liquid at boiling point.	Color of liquid.
	Below.	Atmos.			mm.			
Hydrogen (H_2)	—220·0°	20·0	?	?	?	1·0	?	Colorless.
Nitrogen (N_2)	—146·0	35·0	—194·4°	214·0°	60	14·0	0·885	"
Carbonic oxide (CO)	—139·5	35·5	—190·0	—207·0	100	14·0	?	"
Argon (A_1)	—121·0	50·6	—187·0	—189·6	?	19·9	About 1·5	"
Oxygen (O_2)	—118·8	50·8	—182·7	?	?	16·0	1·124	Bluish.
Nitric oxide (NO)	—93·5	71·2	—153·6	—167·0	138	15·0	?	Colorless.
Methane (CH_4)	—81·8	54·9	—164·0	—185·8	80	8·0	0·415	"

As can be seen from the foregoing table, argon belongs to the so-called "permanent" gases, and, as regards difficulty in liquefying it, it occupies the fourth place, viz., between carbon monoxide and oxygen. Its behavior on liquefaction places it nearest to oxygen, but it differs entirely from oxygen in being solidifiable; as is well known, oxygen has not yet been made to assume a solid state.

The high density of argon rendered it probable that its liquefaction would take place at a higher temperature than that at which oxygen liquefies. Its unexpectedly low critical temperature and boiling point seem to have some relation to its unexpectedly simple molecular constitution.

After the reading of the foregoing paper a discussion followed, of which we give the most important parts.

Dr. H. E. Armstrong said that the case for the existence of the new constituent was undoubtedly a very strong one, and would, no doubt, meet with very considerable criticism throughout the world. But, apart from the facts which were brought forward, there was a portion which was of a wildly speculative character, viz., the portion dealing with the probable nature of this new element. Apparently the authors were not entirely satisfied with the evidence to be adduced from the application of the Clausius method for the determination of the atomicity of the gas. It was quite conceivable that the condition which Prof. Ramsay pointed out as being the only alternative to the one which was apparently accepted by the authors of the communication is a conceivable condition. It was quite likely that the two atoms existed so firmly locked in each other's embrace that there was no possibility for them to take notice of anything outside, and that they were perfectly content to roll on together without taking up any of the energy that is put into the molecule. The spectroscopic evidence was not sufficient to justify the conclusion that the new gas was a mixture. The great difficulty in accepting the conclusion that the gas was an element having a molecular weight of 40 and an atomic weight of 40 arose from the difficulty of placing an element of that kind. All these matters, however, would have to be discussed later on more fully; they were matters which could only be discussed very gradually, as more was learned about the new substance.

Prof. A. W. Rucker said that the one certain fact which came out indisputably from the facts described by Prof. Ramsay was that in spite of the doubt which may have existed on the matter for the last few weeks or months, it was certain that they had now a new constituent of the atmosphere. It seemed to him that one of the most interesting results arrived at from the physical point of view was the fact that the gas was monatomic, arguing from the determined ratio of the specific heats. The experiments carried out by Lord Rayleigh and Prof. Ramsay made it certain that the element had the particular ratio of specific heats mentioned. Well, then the question arose, What followed from this? In order that this ratio might be obtained it was necessary that the atom with which they were dealing should be regarded as spherical. In conclusion he said that whatever the effect might be upon the great chemical generalization of Mendeleef, that was, after all, an empirical law based at present upon no dynamical foundation. If it held its own in this case, it would, of course, strengthen the belief in it, but, on the other hand, the law did not stand on the footing of those great mechanical generalizations which could not be upset without upsetting the whole of our fundamental notions of science.

Prof. Roberts Austen remarked that in the Bessemer process alone some ten tons of iron were put into a vessel called a converter. During the conversion no less than 100,000 cubic feet of air passed through the fluid iron. Therefore 1,000 cubic feet of argon went somewhere. He had taken Bessemer-blown metal which had not been treated with ferro-manganese and pumped out forty times its volume of gas, of which one-twentieth was nitrogen. In that nitrogen he had not been able to detect any argon that could not have come from the water which was necessarily used in the manipulation. It remained to be seen whether the argon found its way into the iron, and if it stayed there, whether certain peculiarities that made Bessemer metal different from other kinds of steel could be traced to some of this 1,000 cubic feet of argon, which had either passed into the air or into the iron.

Lord Rayleigh, in the course of his remarks, referred to the argument in favor of the monatomicity of the gas. Of course, what was directly proved by the experiment was that the whole, or nearly the whole, of the energy put into the gas when it was heated was devoted to increasing the energy of its translatory motion, and that no margin remained over to be attributed to intermolecular or interatomic motion. At first sight it seemed rather a strange thing that there should be no rotation in the molecules of the gas. That condition was met by the suggestion which had been put forward and which had also been communicated by Prof. Fitzgerald in the following words: "The reason why the ratio of specific heats of 1·66 is supposed to prove monatomicity in a gas is because in a monatomic gas there are no internal motions of any consequence. Now, if the atoms in a molecule are so bound together that hardly any internal motions exist, it would, so far as specific heat is concerned, behave like a monatomic element. That the atoms in argon may be very closely connected seems likely from its very great chemical inertness. Hence the conclusion from the ratio of its specific heats may be, not that it is monatomic, but that its atoms are so bound together in its molecule that the molecule behaves as a whole as if it was monatomic." It was difficult to conceive the possibility of such an eccentrically shaped atom as that to move about without acquiring a considerable energy of rotation. He, therefore, thought that the only interpretation was that the gas was monatomic.

Lord Kelvin remarked as to the condition under which the ratio of the specific heats could be exactly 1·66, that he did not admit that a spherical atom could fulfill that condition. A spherical atom would not be absolutely smooth. In other words, it must be a Boscovitch point. In fact, the only kind of atom that could be conceived as giving in the dynamical theory of heat rigorously the ratio 1·66 for the specific heat, was the ideal Boscovitch mathematical point endowed with the property of inertia, and with the other property of acting upon neighboring points with a force depending upon distance.

ON THE SPECTRA OF ARGON.*

THROUGH the kindness of Lord Rayleigh and Professor Ramsay, I have been enabled to examine the spectrum of this gas in a very accurate spectroscope, and also to take photographs of its spectra in a spectrograph fitted with a complete quartz train. The results are both interesting and important, and entirely corroborate the conclusions arrived at by the discoverers of argon.

Argon resembles nitrogen in that it gives two distinct spectra according to the strength of the induction current employed. But while the two spectra of nitrogen are different in character, one showing fluted bands and the other sharp lines, the argon spectra both consist of sharp lines. It is, however, very difficult to get argon so free from nitrogen that it will not show the nitrogen flutings superposed on its own special system of lines. I have used argon prepared by Lord Rayleigh, Professor Ramsay, and myself, and, however free it was supposed to be from nitrogen, I could always detect the nitrogen bands in its spectrum. These, however, soon disappear when the induction spark is passed through the tube for some time, varying from a few minutes to a few hours.

The pressure of argon giving the greatest luminosity and most brilliant spectrum is 3 mm. (The best pressure for nitrogen is 75 or 80 mm.) At this point the color of the discharge is an orange red, and the spectrum is rich in red rays, two being especially prominent at wave lengths 696·56 and 705·64. On passing the current the traces of nitrogen bands soon disappear, and the argon spectrum is seen in a state of purity.

If the pressure is further reduced, and a Leyden jar intercalated in the circuit, the color of the luminous discharge changes from red to a rich steel blue, and the spectrum shows an almost entirely different set of lines. The two spectra, called for brevity red and blue, are shown on the large map, the upper spectrum being that of "blue" argon, and the lower one that of "red" argon. It is not easy to obtain the blue color and spectrum entirely free from the red. It appears that a low electromotive force (3 cm. spark, or 27,600 volts) is required to bring out the red, and a high E.M.F. and a very hot spark for the blue. The red glow is produced by the positive spark and the blue by the negative spark.

I have taken photographs of the two spectra of argon partly superposed. In this way their dissimilarity is readily seen.† In the spectrum of the blue glow I have counted 119 lines, and in that of the red glow 80 lines, making 199 in all. Of these 26 appear to be common to both spectra.

The disappearance of the red glow and the appearance of the blue glow in argon as the exhaustion increases also resembles the disappearance of the red line of hydrogen when exhaustion is raised to a high point.

I have prepared tubes containing other gases as well as nitrogen at different pressures, and have examined their spectra both by eye observations and by photography. The sharp line spectrum of nitrogen is not nearly so striking in brilliancy, number or sharpness

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* Abstract of a paper by Dr. K. Olszewski, professor of chemistry in the University of Cracow.

† Bulletin international de l'Academie de Cracovie, June, 1890; also Wiedemann's Beiblatter, vol. 15, p. 29.

‡ I have redetermined the boiling point of oxygen, using large quantities of oxygen and a hydrogen thermometer of much larger dimensions than previously. The registered temperature is 1·3° lower than that which I previously recorded.

* Abstract of a paper by Mr. William Crookes, F.R.S.

† Photographs of the different spectra of argon and other gaseous spectra for comparison were projected on the screen.

of lines as are those of argon, and the most careful scrutiny fails to show any connection between the spectra. I can detect no lines in common. Between the spectra of argon and the band spectrum of nitrogen there are two or three close approximations of lines, but a projection on the screen of a magnified image of the two spectra partly superposed will show that two at least of these are not really coincidences.

I have found no other spectrum-giving gas or vapor yield spectra at all like those of argon, and the apparent coincidences, in some of the lines, which on one or two occasions are noticed, have been very few, and would probably disappear on using a higher dispersion. Having once obtained a tube of argon giving the pure spectra, I can make no alteration in it, other than what I have explained takes place on varying the spark or increasing the exhaustion when the two spectra change from one to the other. As far, therefore, as spectrum work can decide, the verdict must, I think, be that Lord Rayleigh and Professor Ramsay have added one, if not two, members to the family of elementary bodies.

THE TWO SPECTRA OF ARGON.

[Lines having intensities below 8 have been omitted.]

Blue.		Red.	
Wave length.	Intensity.	Wave length.	Intensity.
		705·64	10
		696·56	9
		640·7	9
603·84	8	603·68	8
		565·1	9
		561·0	9
		555·70	10
		549·65	8
		518·58	10
		516·5	9
514·0	10		
506·5	10		
500·7	9		
496·55	9		
493·8	10		
487·9	10		
		470·12	8
460·80	8		
450·95	8	450·95	9
442·65	10		
442·35	10		
439·95	10		
437·65	9		
436·90	9		
434·85	10		
433·35	9	433·35	9
		430·05	9
429·90	9		
		427·20	8
425·95	8	425·95	9
420·10	10	420·10	10
419·80	9	419·80	9
419·15	9	419·15	9
418·30	8	418·30	8
416·45	8		
415·95	10	415·95	10
410·50	8		
407·25	8		
404·40	8	404·40	9
401·30	8		
394·85	9	394·85	10
392·85	8		
		390·45	8
386·85	8		
385·15	10		
378·08	9		
376·60	8		
372·98	10		
358·70	10		
358·03	9		
357·50	9		
349·00	10		

The totals are:

119 lines in the "blue" spectrum.
80 lines in the "red" spectrum.

199 total lines.
26 lines common to the two spectra.

THE INFLUENCE OF THE BICYCLE IN HEALTH AND IN DISEASE.*

By GRÆME M. HAMMOND, M.D., New York, Professor of Diseases of the Mind and Nervous System in the New York Post Graduate Medical School and Hospital; Professor of Mental and Nervous Diseases in the University of Vermont.

ABOUT two years ago I called attention to the treatment of certain diseases of the nervous system by the proper use of the bicycle.† This was the first attempt, at least in this country, to call the attention of the medical profession to a therapeutic agent undoubtedly of great value. At that time comparatively few physicians had had any practical experience with the bicycle, but since then wheeling has taken hold of the popular fancy to such an extent that thousands now ride where formerly hundreds rode, and the medical man who at one time considered bicycle riding degrading to his professional dignity now joins with his lay brothers in the pursuit of health and pleasure on the wheel. The universal popularity of the wheel—and it seems to be growing in favor every year—has undoubtedly not only been a source of great pleasure to thousands, but must also have had an appreciable effect upon the health, either beneficially or the reverse, and physicians are now arriving at a more intelligent conception of the possibilities of the wheel, both for good and for evil. The medical journals of this and foreign countries are daily adding to the literature of the subject by the reports of diseases which seem to have been induced or are aggravated by the use of the wheel.

The question concerning the deleterious effect on the human organism by the injudicious use of the wheel concerns the numerous specialists in medicine as well as the general practitioner. There is hardly an organ in the body which may not be influenced one way or the other by the proper or improper use of the bicycle; and hence it is that all medical men should study this question carefully and endeavor to arrive at the exact facts of the case. To this purpose I propose to consider the subject from the following standpoints: 1. The use of the cycle by persons in health. 2. The use of the cycle by persons diseased.

Little need be said about the rational use of the bicycle by healthy persons. It is only when the wheel is improperly or immoderately used that it constitutes a source of danger. The question will at once arise as to what constitutes this moderate and rational use. As men differ, among other things, in points of age, temperament, physical strength, and power of endurance, so is it absolutely impossible to prescribe any general rule which will be applicable to all men. Each individual must formulate rules for his own guidance, and if he is incapable of doing this, either because he has not arrived at years of discretion or because he recognizes his ignorance and distrusts his judgment, his medical adviser should be consulted, who by studying his physique, heart measurement, and lung capacity, can judge with considerable accuracy the amount of exercise which is most conducive to healthy physical development. But, as a general rule, the average individual, after a fair amount of experience, becomes quite competent to determine his own capabilities and requirements.

Let it be granted that an individual uses the wheel properly, what results should be reasonably expect to achieve? Statistics do not supply any information on this subject. No attempt has yet been made, that I am aware of, to study the physical development of men who have been using the bicycle properly for years. I say for years, because the best effects of any form of exercise which is practiced for the purpose of obtaining physical development are never obtained rapidly, and, particularly in young subjects, should only be studied after several years of continuous culture. There being no available literature on the subject, I am obliged to depend solely upon my own observations. This source of information must necessarily be very meager. Although there are thousands who ride, there are comparatively few within my reach who have been riding long enough to render statistics on their physical development of much value. I have, however, collected fourteen cases of amateur riders who have kept accurate records of the years they have been riding, and approximate records of the number of miles they have ridden in this time. These cases I have examined and endeavored to tabulate the most important features ascertained. These men have ridden from five to thirteen years, and in that time have traveled from five thousand miles to twenty-seven thousand miles.

TABLE NO. 1.—AMATEUR RIDERS.

Case.	Age.	Ridden a Wheel. Years.	Miles Ridden.	Chest Expansion. Inches.	Heart.	Muscular System.
1	37	5	22,000	1¼	Slight hypertrophy.	Well developed.
2	25	10	27,000	1¾	" "	Legs well developed, arms and trunk fair.
3	36	5	8,000	2	" "	General development greatly beyond normal.
4	42	12	24,000	1½	" "	Well developed.
5	46	13	25,000	1	Normal.	Average.
6	24	13	11,000	1⅞	Slight hypertrophy.	Well developed.
7	25	10	30,000	1¾	" "	" "
8	34	7	18,000	1½	" "	" "
9	30	8	9,000	1⅜	Normal.	" "
10	29	7	8,000	1⅞	Slight hypertrophy.	" "
11	26	7	17,000	2	" "	Generally very muscular.
12	24	6	7,000	1¼	Normal.	Average.
13	30	5	6,000	1½	"	"
14	24	5	5,000	1½	Slight hypertrophy.	Well developed.

Average chest expansion, 1½ inch. Heart usually hypertrophied without dilatation. Average age, 31 years. Chest expansion, 13 riders above normal; 1 normal.

This table demonstrates two important facts very clearly. First, that men who have ridden a great deal for a number of years have acquired simple cardiac hypertrophy without dilatation; and second, that their breathing capacity is greatly in excess of that of the average man. The cardiac hypertrophy that I refer to is due to a simple increase of muscular tissue, and is in the nature of a healthy growth or development induced by exercise. It is precisely similar to the hypertrophy which occurs in any other muscle which has been used a great deal. Hypertrophy in this sense is purely a relative term. For more than a century man has shown a tendency to develop the different qualities of the mind, and has paid but little attention to the gradual degeneration of the muscular system and to the consequential reduction of his powers of physical endurance. This has been one of the natural consequences of the rapid advance of civilization, especially in this country, and this, together with the great development of industries, commerce, and the professions, which have demanded the best energies of our men, finally made us a race of intelligent, clear sighted, energetic, and nervous people, but very far short of the physical perfection seen in men in earlier ages. The dangers attending this physical degeneration of the race have of late years been gradually instilled into the public mind, and this has resulted in a healthful reaction. Men, and, what is of almost equal importance, women, are gradually beginning to comprehend the advantages of physical development, and are in a fair way to understand that the highest type of man, taken as a whole, is not represented by intellectuality alone, but more properly by a judicious combination of mental and physical vigor. Ten or fifteen years ago it was exceptional to find business and professional men and women who practiced any special form of exercise. To-day thousands are making physical exercise an important feature of their daily duties; and what is of greater importance, we are educating our children to believe in physical culture and to practice it. The evolution of the bicycle to the form it presents to-day is probably the greatest factor which has influenced the spread of the doctrine of physical culture in this century. As a natural consequence of this gradual but universal physical development, which will only be attained in time, we must expect to observe a relative development of some of the internal organs, particularly of the heart and lungs. The simple hypertrophy of the heart observed in most bicycle riders who have ridden to any extent will gradually become more common, and finally will be accepted as normal, and what is known to-day as the normal heart will then be considered degenerated.

A second glance at the table shows that all the riders have a greater breathing capacity than the average man. The chest of the average man expands an inch when the lungs are inflated to their greatest capacity. This has been carefully verified by myself and by others, who have measured many men whose lung powers have not been developed by special forms of exercise. It is usually believed that the average chest expansion is three inches, and there are many who can increase the girth of the chest much more than this. It is claimed, for instance, that Sandow's expansion is thirteen inches. This, however, is fallacious and does not by any means express the truth. It is accomplished by a forced expiration before the inspiration, and is then further augmented by "setting" the scapular and pectoral muscles. In the table I have prepared the average lung inflation is represented by a chest expansion of one and four-sevenths of an inch, which is an excess of four-sevenths of an inch above that of the average man.

This excess is unquestionably of great advantage to the individual possessing it, when it is taken into consideration what a great influence is exerted on the general health and on the proper performance of the functions of the various organs by a perfect oxygenization of the blood; and when there is added to this the action of a powerful, muscular heart, it can readily be perceived that bicycle riding, conducted properly and for a long time, induces a condition of cardiac and pulmonary development which must exert an enormous influence in maintaining the proper functions of other organs; in preparing the organism to resist disease; and in overcoming disease that has been contracted.

The muscular system of the bicycle rider is, as a rule, uniformly well developed. It is often claimed by those who are not properly informed, that the exercise develops the muscles of the legs at the expense of the rest of the body. This is not so. On the contrary, the muscles of the back, chest, arms, and abdomen are employed a great deal—not to the same extent as the muscles of the legs, but sufficiently so to consider bicycle riding an exercise inducing general development of the muscular system.

The observations recorded in table No. 1 were made on men who have always ridden in the erect posture. A great deal has been said in regard to the pernicious effects of riding with the body almost, if not quite, at a right angle with the legs. A peculiar malformation of the spine has been reported to result from this posture, and it certainly seems as if the lungs, and consequently the heart, must be greatly hampered in performing their work. To obtain some information on this subject I have carefully examined fourteen professional riders, seven of whom are the most celebrated racing men in the world—men who have obtained national reputations as great riders; who have ridden more races than any other men; and who have ridden faster than any other men; and who always ride with the body at right angles to the legs. These observations I have tabulated in table No. 2. In no case was there any deformity of the spinal column, and I may say here, if any such condition has ever been observed, the number of cases of it must be very few indeed. I have never seen a case of it. They were all well built, muscular men, but differed from those in table No. 1, who were all amateurs, in that in all cases there was an excessive development, compared to the rest of the body, of the muscles of the thighs, particularly of the vastus internus and of the muscles of the abdomen.

The development of the abdominal muscles resulted from their continual contraction while maintaining the riders in their racing position. All had cardiac hypertrophy without dilatation. At first glance it would seem as if the lung capacity of the professionals was fully as good as that of the amateurs, and this is true if the measurements of the national champions only are considered.

Table No. 2 gives the measurements of fourteen celebrated professional riders. Table No. 1 gives the same measurements in an equal number of amateurs. Comparing the measurements of amateur riders with those of the professionals, who are national champions, very little difference can be observed. These men who ride at racing speed, doubled up like a jackknife, were as well developed, had just as powerful and healthy hearts, and their lungs could consume as much oxygen as those who sat upright and rode at moderate speed. But it must not be concluded from this that I mean to infer that any man can race and ride in the posture of a racer with impunity. Far from it. These men became professionals because they found that nature had particularly adapted them for fast riding. They make a business of it, and are always in the best possible physical condition.

If we turn, however, to the measurements of the other six professionals, whose inferior capabilities have not allowed them to become national celebrities, we find a very different state of affairs. One has the normal chest expansion of one inch, four below normal, and one is above normal. The latter, however, has been racing but a short time, having recently graduated from the amateur ranks. Comparing the fourteen amateur riders with the fourteen professionals, it will be see that the average chest expansion of the amateurs is 1½ of an inch, while that of the professionals is 1¼ of an inch. The expansion of thirteen amateurs is above normal, and in one it is normal. With the professionals the expansion is above normal in eight, normal in

* Read before the New York Academy of Medicine, December 19, 1894.

† Journal of Nervous and Mental Diseases, January, 1892.

TABLE NO. 2.—PROFESSIONAL RIDERS.

Names.	Age.	Remarks.	Chest Expansion. Inches.	Heart.	Muscular System.
Zimmerma'n	24	American world's champion.	1¼	Hypertrophied.	Well developed. Extraordinary development of abdominal and thigh muscles.
Wheeler	25	American. Celebrated rider.	1⅜	"	Well developed. Extraordinary development of abdominal and thigh muscles.
Blounts	23	England's champion.	1⅜	"	Well developed. Extraordinary development of abdominal and thigh muscles.
Verbeyn	30	Germany's champion.	1½	Slight hypertrophy.	Well developed. Extraordinary development of abdominal and thigh muscles.
Colombo	23	Italy's champion.	2	Slight hypertrophy.	Very muscular. No special development.
Lesna	31	France's 24-hour champion.	2	Slight hypertrophy.	Very muscular. No special development.
Martin	25	America's 6-days champion.	2	Hypertrophied.	Very muscular, especially in the thighs.
Albert	28	American. 6-days rider and short distance racer.	1¼	"	Too slender for his height. Muscles not at all prominent except in abdomen.
Berio	28	American. Short distance racer.	⅞	Hypertrophied, but not strong.	Muscular thighs and abdomen. Chest somewhat sunken.
Knowles	40	American. 6,240 miles in 60 days' racer.	¾	Hypertrophied.	Very muscular.
Foster	40	German. Long distance rider.	¾	"	Normal development.
Gross	28	American. Short distance racer.	1	"	Well developed.
Murphy, W. F.	25	American. Class B racer.	⅞	Hypertrophied, but not strong.	Not at all muscular except in thighs and abdomen.
Macdonald	18	American. Class B racer.	1¼	Normal and very strong.	Small but well developed.

Average age, 27 years. Average chest expansion, 1⅛ inch. Chest expansion, 9 above normal (these are celebrated riders); 1 normal (1 inch); 4 below normal.

one, and below normal in four. It is quite probable, if professional riders of less phenomenal abilities were substituted in the second table in place of the national champions, the average chest expansion would be found to be below normal.

Excessive work on the wheel is, for the average man, unquestionably injurious, and it seems a fair inference to draw, from a study of these cases, that while many men will, in the course of time, ascertain that nature has adapted them so they may race with impunity, for a time at least, others who are led to emulate their example will certainly injure their health and undermine their constitution. This is particularly true of young lads, many of whom consider themselves the coming racing champions of the world. They can be seen in the streets and on the country roads, tearing along at the top of their speed, the body thrown forward, the back humped and the arms fixed and rigid, the chest necessarily contracted and preventing its proper expansion, at the very time when free movement of the chest walls is most necessary. In such cases healthy development is likely to be arrested and cardiac dilatation, impoverishment of the blood and lowered vitality of the system are probable consequences. Parents and physicians should use their authority to prevent this abuse in the rising generation, and a youth who will not ride properly should not be allowed to ride at all. It has been claimed that appendicitis can be sometimes attributed to this faulty position in riding. While it is undoubtedly true that persons who ride the wheel, no matter in what posture they ride, may have appendicitis, there is nothing in literature to prove any direct relation between appendicitis and bicycle riding as a cause and effect.

Riding great distances at rapid speed is an abuse of the wheel which cannot be too severely condemned. Any one who witnessed the last six days' bicycle race, about a year ago, cannot but recall with disgust the sickening exhibition of exhausted riders, having to be lifted from and onto their wheels and carried to and from their quarters, their joints swollen and inflamed, barely able to see, and only kept in a conscious condition by the united efforts of trainers and physicians. This, however, is an extreme case, but it is not at all uncommon for large parties of riders of both sexes to go on what are called "century runs," that is, to ride a hundred miles often within a limited number of hours. To many riders of experience, who are in good condition and possess excellent powers of endurance, this may not be a difficult feat to perform, but many others in making the attempt suffer from exhaustion which leaves its traces for several days. There are others again, who travel shorter distances, but who ride at such speed that they return home thoroughly tired out. This, if it occurs only occasionally, is perhaps of little moment, but when the repetition is frequent it is undoubtedly injurious.

Moderate exercise, properly performed, invigorates the system, strengthens the muscles and increases the powers of physical endurance, but excessive and exhaustive exercise does none of these things; on the contrary, it is decidedly injurious to health and should never be encouraged. Under certain conditions diseases of the genito-urinary tract may with great probability either be induced, or else, if they already exist, they may be aggravated. Cases of prostatitis, urethritis and cystitis have been reported, which seem to show quite conclusively that the friction or jolting of the perineum against the saddle was the exciting or aggravating cause. Such cases are due to the carelessness or ignorance of the rider. An individual in riding the cycle, just as in riding the horse, should sit upon the gluteal muscles and not upon the perineum. All bicycle saddles can be tilted either forward or backward, and every person who rides should so adjust the saddle that the weight of the body is borne by the gluteal muscles and not by the perineum, otherwise it is quite probable that injurious results may follow. In regard to the excitation of the genital organs in both sexes, I am quite confident that this never occurs, unless it is done purposely or else by the greatest negligence. A woman who wishes to obtain friction of her genitals on the wheel can easily do so by adjusting her saddle for that purpose. But if she does so, her position will be so uncomfortable as to deprive riding of all enjoyment. She may ride for the purpose of obtaining genital irritation, or she may ride with perfectly proper motives, but she cannot do both at the same time.

In the male the case is different. Riding upon the perineum may in many instances cause genital irritation, but this can be effectually prevented by the proper adjustment of the saddle. It can therefore be seen that these diseases or conditions are by no means necessary consequences of bicycle riding. On the contrary, they can be remedied in all cases by the intelligent comprehension of the wrong and its remedy.

The question is often asked, Shall women suffering from abnormal conditions of the uterus and ovaries ride a wheel? I was much pleased, at a recent meeting of the Gynecological Section of the Academy, to listen to the opinions of our leading gynecologists on the subject. It seemed to be the general opinion that this form of exercise was not only not injurious, but that in many cases of disease it was highly beneficial, either as a means of relieving local congestion, or else acting indirectly on the pelvic organs by improving the general health of the patient.

There is one other condition which deserves mention, and which I am not aware has called forth any comment up to the present time, and that is the effect of bicycle riding on the air passages and as a cause of mouth breathing. On examination I found all of the men enumerated in table No. 2, and who were professional riders, breathed through the mouth while riding, and that eight of these were habitual mouth breathers. The majority of the amateur riders I have questioned on this subject admit that they breathe through the mouth while riding, but whether the proportion of mouth breathers is greater among cycle riders than among those who do not ride, I do not know, but it is a matter that deserves investigation.

The use of the wheel by persons diseased, when considered in the light of a therapeutic agent, is a subject of considerable importance. It also leads us to inquire whether there are not physical conditions under which the bicycle should be absolutely prohibited. In certain diseased conditions of the heart, bicycle riding may prove very beneficial. In simple degenerated conditions of the muscular fibers, in dilated hearts either with or without compensatory hypertrophy, and in slight valvular affections, bicycle riding, when properly practiced, may prove of great service, because it improves the nutrition of the organ and develops the muscular fibers, thereby enabling the heart to perform its work more effectually. But no one suffering from any cardiac affection should ever ride a wheel, unless advised to do so by his physician; and in such instances the physician should make frequent examinations in order to determine whether benefit is being derived from it or not. Where exercise is advisable in heart affections, I know of no better method of obtaining it than by the proper use of the wheel. By riding slowly and on an approximately flat surface the mildest cardiac exercise can be obtained, and this, as the heart improves in strength, can be increased by degrees and in direct ratio with the cardiac development. By this means the strength of the heart can be greatly increased, thus causing a natural compensation for many abnormal conditions.

But bicycle riding can cause as well as cure cardiac degenerations. If an individual compels his heart to work beyond its capacity and the abuse becomes in any sense continuous, the danger of cardiac degeneration becomes imminent. This is more particularly liable to occur in subjects whose cardiac muscular fibers are abnormally weakened from disease, dissipation, or from long neglect of such exercises as are requisite for maintaining the heart in a healthy condition. In valvular lesions also immoderate riding will unquestionably aggravate existing abnormal conditions, and perhaps superimpose another cardiac disease upon the original one. In short, it may be said that bicycle riding may benefit or injure the heart according to the condition of the heart and the manner in which the individual conducts his exercise, and the general principle may be adduced that, while the moderate use of the wheel is conducive to cardiac development, the excessive use endangers cardiac degeneration. I cannot agree with the decision of the French Academy, that "no one should ride a wheel without consulting a physician;" but this rule certainly should apply to all persons who have cardiac disease and to all others whose general health, vitality and physical strength are to any degree below the normal. What has just been said in relation to cardiac diseases applies in the main to pulmonary affections. I have already shown, as far as the limited number of cases at my disposal permits, that bicycle riding, when practiced by a healthy person, unquestionably develops the lungs and increases their capacity greatly beyond what is now considered to be normal. The knowledge of this fact may be taken advantage of in the treatment of those pulmonary conditions in which a breaking down of tissue will be the natural and probable consequence in the course of time. Moderate exercise of the lungs by the moderate use of the wheel practiced systematically and for a long time will undoubtedly retard and perhaps completely arrest some degenerative changes in the lungs. This will follow not only from the direct effect of pulmonary development, but also from the generally improved physical condition which is always a prominent feature of bicycle riding when rationally practiced. On the other hand, I can conceive of nothing which will be more injurious to certain abnormal pulmonary conditions than the excessive use of the wheel. Not only will this tend to accelerate degenerative processes, but it may also induce them in persons predisposed, particularly if the general vitality is simultaneously diminished.

The same general rule can be formulated here that seemed to be applicable to the heart, that is: That the moderate and proper use of the wheel results in pulmonary development, while the excessive use may be followed by injurious consequences.

In my former paper I showed, by the report of a number of cases, that in certain diseases of the nervous system bicycle riding was very serviceable. That report referred mainly to cases of functional and organic paralysis and to neurasthenia and hysteria, and demonstrated that in these conditions great improvement was obtained directly from the use of the wheel. My opinions were so fully expressed at that time that it is needless to refer to the subject again, except to state that my experience in the past two years, since that paper was published, fully corroborates the views I then entertained. I only desire to state in addition that I have carefully studied the effects of bicycle riding on numerous cases of functional dyspepsia and constipation, and have observed great benefit in most instances, but only in those cases in which the riding was followed systematically. There are two other conditions I desire to refer to before I conclude what I have to say, in which bicycle riding seems to exert a beneficial influence. These are gout and diabetes. Possibly both of these diseases are benefited by the great quantity of oxygen consumed; by the improvement in digestion and assimilation, and by the effect that prolonged muscular action has on eliminating certain substances from the system which are either poisonous per se or else become so by conversion. In two cases of subacute gout I have prescribed the use of the wheel and have every reason to feel satisfied with the results. In only two case of diabetes have I had the opportunity of making observations in regard to the effect of this exercise on the excretion of sugar. These few cases are not sufficient to allow the presentation of any absolute deductions, but the results obtained were sufficiently encouraging to warrant further investigations in this direction.

If we accept the view that the manifestations of gout depend upon an excessive formation of uric acid in the system, it can be readily understood, theoretically at least, how bicycle riding can modify or arrest this process. First, by the improvement in digestion and assimilation; second, by the greater demand upon the nitrogenous compounds required by the repair of the muscles; third, by the increased oxygenation of the blood, which increases the elimination of urates; and fourth, by the further elimination of morbid material through the increased activity of the sweat glands.

This theory may be susceptible to criticism, but whether it is correct or whether we must look further for the reasons, the fact remains that benefit is derived in these cases from the use of the wheel. In the two cases of diabetes, experimental studies showed that in both cases, and with no change of diet, the amount of sugar excreted was diminished when the bicycle was used regularly. The explanation of this fact seems to be reasonable, and is similar to that just offered in reference to gout. The waste taking place in the muscles is repaired from the nitrogenous elements, which otherwise would be converted into urea and then into sugar.

The larger the muscles are that are wasted, the greater quantity of nitrogenous substance will be required to complete repair. The largest muscles in the body are in the lower extremities, and consequently bicycle riding, which calls these muscles into active use better than any other form of exercise, operates to excellent advantage. The heart also need not be exercised unduly, which, in these cases, is often a point of considerable importance. It is impossible, in an article on this subject, to enter deeply into the discussion of each one of the subjects touched upon without making a paper of interminable length. I will therefore conclude what I have to say by the statement that experience has shown me that bicycle riding for a healthy individual is one of the most excellent forms of exercise for maintaining health, retarding disease and strengthening the constitution, and is also a pleasant recreation for the mind; and that in many forms of disease, when used cautiously and under medical supervision, it will often be found of inestimable advantage.—Medical Record.

[FROM THE NEW YORK SUN.]

CURIOUS HABITS OF BIRDS.

AN amateur naturalist living in Northwood, N. Y., is making a collection of bird skins, mounted in the form of life, and of birds' nests, which is designed, when complete, to show, as well as may be, the many remarkable ways in which bird traits of character are akin to those of human beings. Among these traits none is more likely to interest the reader not learned in matters ornithological than the various ways in which birds amuse themselves, their recreations, so to speak. For bird life is by no means wholly devoted to house building, the search for food and the rearing of the young. For instance, in an article on Patagonia birds which appeared in the Sun some time ago, mention was made of certain birds there that have the habit of going through set performances, much like those of human beings who gather to dance. That habit is not at all peculiar to Patagonia birds. Indeed, there are many more birds who gather to dance outside of Patagonia than within its desert borders.

There is one notable bird in the United States—the turkey buzzard—that is quite a dancer, though no musician. If one will watch a flock of these birds feasting say on a big fish on a beach, he will find that when they have satisfied their appetites they will hop about in a most amusing way, and after a few mock fights will soar away into the air, where they will wheel around in the most graceful fashion by the hour. The common notion that these birds are on the lookout for prey whenever they go high in the air is wrong. They go up there to circle about for the fun of it, just as well-fed boys and girls must needs run and swing their arms when they would play rather than sit down and play in a quiet way.

Another great bird that is somewhat awkward when seen on the ground has the fashion of swinging itself a half mile or so up into the air for pure recreation. This is the chaja, of the Argentine Republic, a bird that is known in the books as the crested screamer and Chauna chavarria. It has a body and neck like those of a slate-blue goose, with legs somewhat like a turkey's, only much thicker and with longer toes. There is a crest on its head and a black collar around its neck, and its eyes are surrounded with red skin. On the whole it presents a striking appearance. This

kind of bird sometimes gathers in bands of hundreds and thousands about the wild marshy places, where it feeds on the grass. When hunger is satisfied the birds get upon their wings, seemingly with prodigious effort, beating the air till there is a sound as of a mighty wind, and away they go, up and up, in sweeping circles, till they all but disappear, and sometimes they do disappear. As they rise they sing or shout to each other in trumpet tones.

Curiously enough, the higher they go, the easier becomes their flight, until they float without effort. This is curious, because the air is thin and less able to support them up there, but probably the increased speed of their motion more than makes up for the thinness of the air. The voice becomes softer and sweeter as they rise, just as the sound of a bugle heard from a distance over the water is more pleasing than when close at hand. Nor are they voiceless or without amusement when on the land. At night, especially, they unite at intervals in a tremendous chorus, and where a number of flocks are found within call of each other they take turn one after another in their song.

One of the most beautiful birds known to tropical America is the jacana, a sort of snipe found along the streams all the way from Mexico to the River Plate, and in unusually great numbers along the outlet of Lake Nicaragua. There is a silky sheen to the feathers, which are chiefly green and gold and chocolate brown, and there are such shadings of one color into another in one place and such contrasts in another that no better description of the birds can be given than to call them living bouquets.

As the steamer goes up the Rio San Juan they may be seen in pairs frequently, either feeding along shore or flying, and they are always very attractive. But if the traveler is lucky, he may see a dozen of the birds suddenly gather from up and down the river at some open place and there form a most curious group. Some stand with wings held straight up in the air and perfectly motionless. Others half open the wings and then flutter them rapidly, and still others wave the wings slowly up and down as butterflies do when gathered in groups. Some stand in place while others move slowly about, but all chirp in the most excited fashion. If the birds gathered purposely to show their beautiful feathers to the spectators they could not adopt a better method, but, of course, this is only the jacana way of having a bit of fun to vary the monotony of looking for food and keeping the eggs in the nests warm.

The strange antics of one fun-loving tyrant bird have given it a name; it is called the scissor tail. It is gray and white, with black head and tail, and a yellowish crest. It is about like a big swallow, but the outer feather on each side of its tail is much longer than the rest, a foot long in the full-grown bird. At sunset these birds gather in small flocks, shouting in great glee, and then away up in the air they go until almost out of sight. There they circle around gracefully a few times and then plunge toward the earth in amazing zigzag motions, working their long tail feathers the while like pairs of scissors and making sharp, short, half whirring, half whizzing sounds that are most remarkable. After that they separate into pairs as they were before for a sociable chorus, and then they are ready to retire for the night.

Another bird whose style of play has given it a name is a kind of finch called oscilader. Rising to a distance of say thirty or forty feet from the ground, it swoops away and down toward the ground, only to rise again to its original height, thus tracing in the air a perfect curve perhaps twenty yards long. Then it turns and swoops back again over precisely the same curve, and so it oscillates like a pendulum until tired.

Down in southern Brazil is a little bird that comes as near to holding a regular darky "hoe-down," a minstrel song and dance, as it is possible for birds to do. It is called "the dancing bird" by the natives, but what the scientific name may be is unknown to the writer. It is a tiny blue bird with a red crest. Mornings and evenings the little fellows gather in a group of a score or so on a smooth, sandy or gravelly spot, or at least a spot that is free of grass or any obstruction. Then one of the males flies to a twig somewhere overhead and begins singing in the jolliest jig voice imaginable, and immediately the birds begin to step in perfect time with the song, and twitter an accompaniment, and more than that, move their wings in time with the music as they step about.

Akin to this dance is one where there is but a single dancer on the floor at a time. The bird is known as the rupicola, or cock of the rock, also a Brazil bird. It is most beautifully dressed in orange and scarlet plumage. Like the little blue bird, it selects a smooth, hard floor as its dancing place, and there must be an abundance of bushes around, for it does not seem to like spectators. About this kind of a platform the birds gather, some on the ground and some on the brush. Then all sing, except one, who gets into the center of the floor and there leaps and gyrates in a most comical fashion until exhausted. Then he staggers off, but another instantly takes his place and repeats his performance, and so they go on, if undisturbed, till every one of them has had his fling.

It is possible some critical reader may say that the hoppings and gyrations of birds should not be called dancing, but in reply to that it may be said that the motions of every bird so far mentioned, even the heavy lopings of the buzzard, are in all cases at least as graceful and rhythmic as the dancing of the aborigines of the two Americas. If such a reader will go among the tribes of the Indian Territory in the green corn time, he can see the natives line up for a dance, the motions of which will consist of simply stamping the feet in plantigrade fashion, first one and then the other, in time with the tum-tum of a drum, while all sing, "Hey-yah, hey-yah, hey-yah, ho!" If that is a dance, then the motions of the birds are dances.

Bates, the naturalist, whose work along the Amazon River made him famous, was chiefly interested in insects, but he tells of two kinds of birds which he observed at play. One was of the family called by the natives pig birds, because of their sluggish habits, but this group was lively enough. They were chasing each other like children playing tag. Chirping and singing the while in the greatest glee, laughing and shouting in bird fashion, in other words. The other was "a brilliant red-headed manikin" (Pipra cornuta). Three of these were seen dancing in a ludicrously solemn fashion, hopping backward and forward, and from each other, with never a peep or bit of sound of any kind to enliven the occasion.

Although as a rule the males among the birds are the most given to the playful antics here described, in many of the families males and females dance together. There is one sort of bird, however, where the females get together—a genuine hen party—and have little mock fights. This is the genus Cinpolegus, found in the River Plate country. This style of seeking amusement—pretending to fight—is as widespread, it may be said, as the bird kingdom. So vast a number of bird species do this that no enumeration of them is possible, but if any one will watch the robins when they first come this spring he will see many a boxing match, so to speak, which though brief will be spirited and perfectly good natured withal.

There is in Central America a bird called sarrate by the natives, that can always be found around the cattle. It has a curious way of enjoying itself. A group will gather on smooth ground or on a cattle shed, and one will ruffle out its feathers, spread its wings a bit, take two steps forward, stretch out its neck to full length, and then with wide-open mouth make a whistling sound. Then it instantly closes down wings and feathers to place, and raising its head, with the bill to the zenith, it stands rigid for a moment. After this it returns to its place and another takes a fling as it had done.

Interesting as the pastimes of the birds so far mentioned must be when seen by any one who has even a little love for nature, more wonderful things remain to be told. There is a bird, for instance, the crimson-beaked weaver of Africa (Quelea sanguinirostris), which is as much like a bad boy at school as one need wish to see, for his favorite pastime is pestering smaller birds in a most ridiculous fashion. At every convenient opportunity this audacious rascal catches another bird by the tail and holds it, while the captive flutters and screams in anger, for several seconds. Then he lets it go again and chirps (chuckles) with malicious glee.

But most remarkable of all birds in the world in their pastimes are the bower birds, for they not only get together to play and dance, but they actually build bowers and pavilions in which to carry on their revelry. The Amblyornis inornata of Papua selects as the place for building its bower a level piece of ground about the base of a sapling that is say half or three-quarters of an inch in diameter. Against this tiny tree it places slender poles nearly a yard long, precisely as a woodsman would do when making a circular bark shanty around the base of a tree. These poles have forks at the top, too, as the woodsman's would have, and enough of them are put up to form rafters for a shanty entirely around the center pole. In and out among these rafters the birds (working in companies) weave stems of grass and bits of leaves until they have a waterproof roof, but a roomy, arched entrance is left on one side. About the center pillar a large embankment of moss is built, but the object for which this is done is not known. One observer has suggested that they build it in order that the center pole may be "held firmly in place," but of course a pile of soft moss could not add firmness to a sapling. Next they build a gallery of moss all around the interior circumference of this assembly room, and then the structure is done. The amount of work involved can be imagined when it is calculated that this club house, so to speak, is about four feet in diameter and twenty inches high, and that the gallery is about eleven feet long.

Nevertheless, even when the house is done, they are not ready for the house warming; they must first make a lawn. Beginning at the doorway, the birds cover over a lawn or front yard as large as their house floor with a soft carpet of moss, and then decorate this lawn with no end of bright flowers, the gaudy wings of butterflies, high-colored fruits, anything that will show in brilliant contrast with the dark green mosses. And while they are decorating the lawn they continue their artistic work to the gallery within, until it, too, flashes its beautiful colors from beneath the shade of the roof. And all that is the work of a bird no larger than the American robin.

Another species, Chlamydera maculata, builds a tent 2 by 3 feet large on the ground and rising in a Gothic arch to a height of about two feet. It covers the ground with woven twigs first, making a spring mat floor that any one would say was simply elegant for a dance. The walls are of sticks and grass woven and thatched until rain proof, the first sticks erected being held in place by thrusting the butt ends into the ground and by bracing with stones piled against them. No gallery is built here, but the structure and the lawn are decorated with a greater variety of objects than the other birds use, bits of white bones and shells being common. Moreover, the interior of the pavilion has most beautiful wall hangings; that is it is lined with soft grasses of delicate shades of color, care being taken that no stiff end of a grass stalk projects to mar the soft, fluffy appearance of the wall.

In the case of each of these pavilion builders a house warming is held as soon as the structure is finished. The birds gather in a flock in the happiest of moods. The females perch on the gayly decorated gallery in the one case and against the soft walls in the other, while the males strut about on the floor to exhibit their fine feathers or dance Indian fashion, while all hands sing and flutter in time to the music. And thereafter these play houses are places of daily resort.

There is one very interesting fact about all of these ways in which birds show their fun-loving dispositions, and that is that the various antics are most noticeable after the birds have paired, have selected mates. The notion that the Brazilian birds get together for a darky hoe-down, or the bower birds build their pavilions in order that the females may have a chance to see all the aspirants, and so make conscious selections because of the special brightness or the special length of crest on this or that male dancer, does not stand the test of observations in the field. Among a few birds there is a competition between males when mating begins, during which each male seems to be trying to exhibit itself to the best advantage before the critical female. The common yellowhammer is a most excellent example of this, but even there it is not safe to say that the female selects her mate because of his beauty. It may be because of his grace instead, or because of the attractiveness of his voice, or because of some quality which human sight is unable to perceive. As for the great majority of birds, the male is more devoted and more energetic in the display of his beautiful plumage and sweetness of voice and grace of action after mating than before.

Any consideration of bird habits shows some very human-like traits in what the birds do in the sober relations of life as well as in their antics when playing. The wood hewer family—the tree creepers and oven birds, for instance—show some traits worth considering by married people. The oven birds, called house nest builders by the Guarani Indians of the Parana, mate for life, and are not only faithful to each other, but show a remarkable affection one for the other. They usually, though not always, hunt together, and if for a time they are separated by even a small distance they keep calling to each other constantly. When the young are hatched and one bird finds a bit of food to carry to the nest the other one goes along, although it has nothing—goes just for company. And when after a separation they meet again, they shout with joy one to the other.

In startling contrast to the oven birds are the black and red tanagers, found in abundance in Nicaragua. The male is of a velvety black all over, except a spot just above the tail, that is flaming red. The female is a sober brown. A more ungallant fellow than this male tanager would be hard to imagine. It lives in a region of many dangers, and hawks are ever present, so what does this tanager do when he wants to cross an open place but send his wife ahead. If she reach cover without attack, then he will follow. Of course, he hides himself as quickly as possible on reaching the sheltering bushes. And yet, such is the peculiarity of the female taste, this cowardly scamp is such a popular fellow that he always has half a dozen of females around him; he is a polygamist.

As house builders there are some birds that show very much greater skill than many tribes of aborigines do. Take the oven birds, already mentioned, as an example. Their nest is made of clay, shaped something like an oven, and is of prodigious size and strength. There are kingfishers that make burrows that for warmth and comfort equal the dugout common in western Texas. There are birds that weave nests, which they attach to reeds and calk with clay until they are rain and storm proof, and yet too light to weigh down the reeds. There are birds that make nests on the waterpot model. A tubular passage of small interlaced twigs runs down like the spout of a waterpot or teapot and then turns up into a great room, whose walls are a solid mass of clay and sticks.

The baya (Nelicurvius), of southeastern Asia, builds a two-story, three-room nest which it suspends from a handy limb or the eaves of a cottage. There is an entrance at the bottom to a large living room, where the whole family gather when the young have been hatched. Above this are two rooms, one where the female lays her eggs and hatches them; the other is the bedroom of the male. Curious as this nest may seem, its most remarkable feature is in its wall decorations. No sooner is the nest completed than the male goes away and catches fireflies, which he confines in the woven mass without killing them. The walls of his wife's chamber are brilliantly lighted up by these living lamps. Moreover, the living room and even the outside of the nest is also decorated in the same way, and a more beautiful decoration was never used by man.

Let no material-minded reader guess that the fireflies are brought for food. When a firefly dies its body is cast out and a fresh one put in its place. These birds have a distinct sense of the beautiful, as have the garden birds and bower builders already mentioned, who use flowers, butterfly wings, shells, and other bright things when decorating their playhouses.

Probably the most wonderful bird nest in the world is that of the hammer head of Africa. It is a bird twenty inches in length, having a long bill and a crest on the back of its head. It selects a sloping piece of ground and there erects a dome of sticks and mud that is sometimes nearly eight feet in diameter on the ground. The entrance is by a hole on the down-hill side, so that the floor cannot be flooded by a rain. Within this house a level platform is built on the upper side and this is covered over with moss, while a partition is erected from its front edge to make of the platform a bed chamber for the wife. It is there that the eggs are laid and hatched. When the house is done the male devotes his waking hours to supplying the female with food—gathering for use when the weather is bad a stock which he stores in the outer room—and, last of all, in decorating the house. Like the bower builders, he takes everything showing a bright color that he is able to handle and piles it about his house. When he lives near human habitations he carries off such things as spoons, knives, buttons, and thimbles.

Compared with these structures there are to be found very few houses among aboriginal house builders that are superior. The Iroquois log cabin on the Mohawk River in the old days, and the pueblos of New Mexico, were no better for the purpose, and they were certainly never decorated so well. The painted skin tents of the plains Indians showed a barbaric love of color that is just about to be compared with the artistic taste of the hammer bird. Birds, as well as human beings, have a knowledge of the useful, and are blessed with an artistic sense.

There is a plenty of other feelings that are common to human beings and birds, and the birds, like human beings, take action according to their feelings and thoughts. There is, for instance, the fear of a snake. Human beings in the old days probably were persecuted by antediluvian snakes as birds are now persecuted. The traveler who visits the Isthmus of Tehuantepec will find there that the weaver birds, who commonly build their hanging nests on the ends of the smooth and almost leafless limbs of a kind of tree that towers high in air above the surrounding forests in order to escape tree-climbing snakes, have taken to the telegraph wire of the railroad and the line to Oaxaca instead. The writer has seen a score of nests hanging from the wire between two poles. There, at least, is a place where the bird is wholly free from its hereditary enemies, and the species is increasing in numbers since the wires were strung.

Any mention of fear in birds reminds one not only of bird actions when alarmed, but of instances where they showed they were able to reason from cause to

effect. Let a hawk, like the marsh hawk of the Argentine, which Hudson calls the "sharp-winged death," appear, and all the birds scream and cry out in their terror, just as people do. Birds of some kinds when badly frightened are rendered unable to move, just as people stand still before a locomotive that is sure to destroy them. The Antarctic swan may be captured alive by horsemen because of this peculiarity.

On the other hand the marsh hawk mentioned shows a very human-like love of cruelty, for it often dashes at birds it might easily capture, and then, after giving them a great fright, sails away to repeat the action elsewhere.

By returning once more to the woodhewer family we will find one trait that is remarkable in its similarity to one in human beings. These birds are found clear down to the Cape Horn and upon the highest slopes of the Andes. No doubt they are on the Antarctic continent. "Their life is one of perpetual danger, while an exclusively insect diet, laboriously extracted from secret places, and inability to change their climate, contribute to make their existence a hard one" Now, the most striking characteristic of this family is "a methodical, plodding, almost painful diligence of manner." "Viewed side by side with other species, rejoicing in gayer plumage and stronger flight, they seem like sober laborers that never rest among holiday people bent only on enjoyment." In such words is the dominant family of South America described, and it is by diligence of manner and methodical, plodding labor that men become dominant, also are able to exist and even grow rich, not only among the deserts, but in the midst of the keen competition of the crowded districts.

Then there is the love of travel. It is called the migrating instinct by the scientists, but the word instinct does not explain all the doings of birds in this regard. It is, of course, easy to guess that birds go south to escape the cold of winter. It is said that they go north to escape the heat of the tropics; but perhaps they go north because they enjoy the balmy weather of a spring day. Birds may say to each other, "What is so rare as a day in June?" Perhaps they leave the South in spring because they weary of life there and wish a change of scenery. This may seem improbable at first thought, but what must be said of the birds mentioned in the Sun some time ago that nest in Greenland and yet pass the months from September to February in Patagonia? The curlew, the godwit, the plover, in all thirteen different species, travel all the way from the latitude of the Arctic highlands to that of the Tehuelche every year. Is it because of the temperature or the weather that they cross the torrid zone? Scarcely can a man be found who will believe that. It is because they love to travel.

In these later days combinations of capital and effort have been found, among men, to increase profits and cheapen products. When well managed the so-called trusts have been of advantage to all concerned; possibly they have been finger boards to point the way to still greater schemes of co operation. Among birds there have been schemes of co-operation for time out of mind, though it was less than fifty years ago that any one learned the fact. In various parts of the tropics a great variety of birds—fly catchers, tanagers, creepers, woodpeckers, motmots, and so on—gather in flocks of hundreds and set out for a grand round-up of game. They run up and down tree trunks, they scan limbs and logs and leaves, they search every nook and corner where any kind of insect might be concealed. Because all hunt together, they aid one another. The grasshopper that escapes one is caught by another, and so on. They clean up the game as they travel, and they travel rapidly, too. After a couple of hours or so the birds get all they want to eat, and then they separate, to come together when hunger is next pressing them.

This habit has led to an interesting notion among the natives. They observe that one very industrious little creeper is always at the head of the procession, and they conclude that this bird hypnotizes the rest, so to speak, and leads them on this laborious chase from love of leadership. So the skin of a leader has become "great medicine" among the native young women. They believe that such a skin will attract and keep in their train no end of ardent lovers. The lucky fellow who can offer one of those birds to a lassie can ask for what favor he will and not in vain.

The list of bird traits that are like those of human beings is by no means complete in this sketch. The vanity of the peacock and the partridge is familiar to all. There is a bird in Central America with long tail feathers which it actually trims through vanity. All birds show more or less curiosity. The writer once saw a robin show great pleasure, if not gratitude, after a persecuting crow blackbird had been shot off a limb beside it. It flew down to a lower branch, and while looking at the shooter sang the song of joy it always sang when the sun went down.

To show all of these characteristics of birds by means of stuffed skins and other inanimate things will not be possible, but with the aid of photographs and engravings enough may be done to form a collection well worth the trouble and expense.

"Scientists have labored long to show that the human race is descended from the monkey tribe, and very likely they have succeeded, but if any one will put aside prejudice, he will find that in mental qualities the feathered head is as far ahead of that which carries the prehensile tail as that with the tail is ahead of the oyster." So says the backwoods amateur naturalist, and whether he be right or wrong, the reader who will make a study of birds and monkeys can determine for himself.

[FROM KNOWLEDGE.]

THE SMALLEST FLYING SQUIRREL.

By R. LYDEKKER, B.A. Cantab., F.R.S.

IT is a somewhat remarkable fact in natural history that while all true flying mammals, that is to say bats, belong to a single ordinal group, and for all we know to the contrary, may have been derived from one original ancestral stock, this is very far from being the case with those creatures coming under the popular designation of flying squirrels. As we have had occasion to point out in a previous article published in this journal, bats have their fore legs and fingers specially modified for the support of their peculiar leathery wings, and are able to fly in the same manner as birds; whereas, all the flying squirrels have no such modification of the skeleton, and are merely enabled to take long flying leaps from tree to tree by a parachute-like expansion of the skin of the sides of the body, which is supported between the fore and hind limbs of each side, and in some cases extends between the latter to embrace the root of the tail.

In popular natural history the term "flying squirrel" is taken to include certain mammals endowed with this kind of spurious flight inhabiting North America, Asia, Africa, and Australia. So like, indeed, in general external appearance are all these creatures, that it is not surprising to find them all confounded under one general title. When, however, they are examined with the critical eye of an anatomist, they are found to arrange themselves in three main groups, two of which are much more nearly allied to one another than is the third to either of them.* This third group, which is confined to Australia and some of the neighboring islands, has really no right to the name of flying squirrels at all, seeing that it belongs to the order of pouched or marsupial mammals, and has teeth of a totally different type to those characterizing all the rodent order, of which the flying squirrels, properly so called, are members. Accordingly, since these Australian creatures are allied to the ordinary phalangers of the same region, they are more properly spoken of as flying phalangers; and by this name we shall allude to them in the course of the present article.

THE LONG-TAILED WEST AFRICAN FLYING SQUIRREL.
(From the unique specimen in the Berlin Museum from the Cameroons District. Natural size.)

Since these flying phalangers belong to the marsupial order, while the flying squirrels are rodents, it will, of course, be perfectly evident that they have no sort of genetic connection with one another, and hence that their flying membranes have been developed quite independently. If this were all, it would be a very remarkable instance of that "parallelism in development" to which we have alluded in previous articles,* seeing how strikingly similar in external appearance are the members of the two groups.

The marvel does not, however, by any means rest here; since it has been shown fairly conclusively that the three genera into which the flying phalangers are divided by zoologists have been evolved independently of one another from as many non-volant forms. For instance, the great flying phalanger (Petauroides), measuring upward of twenty inches to the root of the tail, is so closely allied to the climbing, crescent-toothed phalanger (Pseudochirus) that there can be no reasonable doubt of its having originated from that genus.

On the other hand, the smaller squirrel flying phalanger and its allies of the genus Petaurus are equally closely related to another non-volant genus known as Gymnobelideus. Finally, the tiny little creature known as the pygmy flying phalanger (Acrobates), which is not so large as a good sized mouse, resembles the little pen-tailed phalanger (Distæcurus) of New Guinea in having the hairs of the tail arranged in rows on the two sides after the manner of the vanes on a feather; and it may accordingly be inferred that the flying type has been evolved from the one which can only climb.

We have here, therefore, not only the parallelism of the parachute of the flying phalangers to that of the flying squirrels, but likewise three independent instances of parallelism in development among the flying phalangers themselves. We must further call the

* We purposely omit mention of the flying lemur (Galeopithaus), which may, perhaps, also at times be called a flying squirrel.

* Republished in "Life and Rock," by the present writer.

reader's especial attention to the great difference in bodily size between the great and the pygmy flying phalanger, since this difference is precisely paralleled among the African flying squirrels.

Leaving the phalangers, we pass on to the flying squirrels preparatory to the consideration of the species forming the special subject of the present article. As we have said, all the flying squirrels in the zoological (but not in the popular sense of the term) belong to the rodent order, the distinctive characteristics of which have been pointed out in an article recently published in this journal, under the title of "The Home of the Rodents." It must not, however, be supposed that all flying squirrels belong to a single genus, or even to a single family. As a matter of fact, they may be assigned to two distinct families. What we may call the northern or typical flying squirrels range over a part of Europe, Asia and North America, and belong to the great family of Sciuridæ, which likewise includes ordinary squirrels as well as marmots, chipmunks or ground squirrels, prairie marmots, etc.

In all these forms the parachute is supported by a rod of cartilage projecting like a yardarm from the outer side of the wrist, and there is another expansion of skin connecting the fore limbs with the neck, while there may be a third between the hind legs and the root of the tail. The whole of these flying squirrels are characterized by the complex structure of their molar teeth; and as their skulls differ considerably from those of other members of the family, they must be regarded as constituting a sub-family group by themselves. Flying squirrels of this group, as we learn from paleontology, have existed since a comparatively early epoch in the Tertiary period, and we are consequently unable to affiliate them with any of the genera of ordinary squirrels; it is, indeed, quite likely that they have originated from a totally extinct genus or genera. Hence, it is impossible to say whether the three genera into which they are divided have all taken origin from one non-volant form or whether, as in the case of the flying phalangers, the power of flight has been separately evolved in each of the three generic groups.

Of the three genera in question, the one known as Sciuropterus includes the lesser flying squirrels, all of which have the crowns of their molar teeth comparatively low, and the parachute of moderate width, and not including any portion of the tail. Having one representative in North America, and a second in northeastern Europe and Siberia, the lesser flying squirrels are mainly characteristic of India and the Malayan countries.

While some of the larger kinds measure as much as twelve inches from the nose to the root of the tail, in the pygmy flying squirrel of Cochin China and Arakan the length of the head and body scarcely exceeds five inches. These squirrels collect in numbers in hollow trees, where they remain in slumber during the daytime, to issue forth at night for the purpose of feeding. Climbing to a coign of vantage on some tree, they take their flying leaps to the bough or trunk of another at a lower level, not infrequently covering a distance of some thirty or forty yards. The length of the leap is, however, still greater among the members of the next genus, reaching from sixty to nearly eighty yards.

The larger flying squirrels (Pteromys) form an exclusively Asiatic group, represented by some ten species, and extending from the Malayan region as far north as eastern Tibet. In addition to their superior dimensions, these flying squirrels are distinguished from the preceding group by the greater width of the parachute along the sides of the body, and the inclosure of the base of the tail in the portion connecting the two hind legs. The tail itself is, moreover, completely cylindrical, instead of slightly compressed; and the molar teeth have rather taller and more complex crowns than in the lesser flying squirrels. In some of the larger species the head and body may measure as much as eighteen inches in length, while the tail may reach to twenty-four or twenty-five inches.

The last member of the family is the woolly flying squirrel (Eupetaurus)—a magnificent species from the neighborhood of Gilgit, distinguished by the very tall molar teeth, which have flat instead of ridged masticating surfaces. It may be mentioned that the first skin of this species brought to England was the property of the present writer, who did not recognize its scientific interest until the arrival of a living example. From having been used as a perambulator rug, it now occupies a position in the British Museum as one of the type specimens of the species.

Although, as already mentioned, we are unable to trace the three genera of typical flying squirrels to as many ancestral non-volant forms, yet it will be seen that these occupy a position in the family Sciuridæ precisely similar to that held by the flying phalangers in the Phalangeridæ. Whereas, however, we have a flying phalanger of dimensions not exceeding a mouse, no member of the typical flying squirrels has such extremely diminutive proportions.

In spite of the circumstance that ordinary climbing squirrels are met with abundantly in Africa, it is remarkable that the typical flying squirrels are replaced by a group so different from the latter that they are regarded by zoologists as constituting a family by themselves—the Anomaluridæ. With the exception of the flying lemurs, these are the only mammals provided with a parachute which constitute a family by themselves; and, so far as we are aware, no suggestions have hitherto been offered as to the family of rodents from which they have originated. These African flying squirrels, as they may be collectively called, differ in several important structural features from their Asiatic allies. In the first place, as is well shown in the accompanying illustration, the parachute is supported in front by a rod of cartilage projecting from the elbow, instead of from the wrist; and an additional peculiarity is to be found in the presence of a row of overlapping horny scales on the under surface of the root of the tail, which are believed to be of assistance in climbing and give the name to the family. Certain structural peculiarities connected with the skull need not be mentioned here.

Hitherto the family has been known only by the short-tailed African flying squirrels constituting the genus Anomalurus; most of the species inhabiting West Africa, although one is found in Equatoria, and a second on the east coast near Zanzibar. The smallest is the equatorial species (A. pusillus), the so-called pygmy flying squirrel, in which the length of the head and body is eleven inches and that of the tail just over five inches.

It is but a few years ago that the last named species was first brought to the notice of science, and with its description most zoologists probably thought that we had exhausted all the interesting representatives of the family, and that nearly the last word had been said about African flying squirrels.

Quite recently there has, however, been discovered in the Cameroons district of Western Africa an entirely new and most interesting representative of the family, constituting a distinct genus (Idiurus), and being by far the smallest of all the known flying squirrels. Of this little creature, which may be known by the name of the long-tailed flying squirrel, we are enabled, by the courtesy of its describer (Dr. Matschie, of the Zoological Museum, Berlin), to give a lifelike figure—the first ever published in this country. This little animal is not larger than a small house mouse, the length of the head and body being only just over two and a half inches, and that of the tail four inches. Agreeing with the ordinary African flying squirrels in the general form and mode of support of the parachute, as well as in the presence of rows of scales on the under surface of the tail, the new species is at once distinguished by the short knob-like nose, and the thinly-haired tail, terminating in a pencil of hairs, and being nearly double the length of the head and body, instead of considerably shorter. In place of being uniformly and thickly covered with fur, the tail is short haired on its upper surface, with three longitudinal rows of elongated sparse hairs, while beneath it is naked, with three rows of scales near the base.

An important difference is also to be found in the structure of the fore foot, in which the thumb is reduced to a mere knob-like rudiment, while in the hind foot the first toe is much smaller than the other four, which are of approximately equal length. There are likewise structural differences in the skull, into the consideration of which it will be unnecessary to enter on this occasion.

In color the fur of the back and upper surface of the parachute is pale whitish-brown, the hairs being blackish-gray at the base, while on the under surface the general hue is a mixture of yellowish and dark gray, with a tinge of silver-gray on the parachute.

At present known only by the single example represented in our illustration, the long-tailed flying squirrel has precisely the same relation in point of size to the largest members of the family as is presented by the pygmy flying phalanger to the great flying phalangers of Australia, and thereby shows us another curious instance of parallelism in development. Of course, nothing is known as to the habits of the new African animal, and comparatively little of those of the pygmy flying phalanger. The latter creature is, however, stated to be very active in leaping from bough to bough of the trees it frequents; and it may be presumed that, in the case of both animals, the flying leaps merely extend from one bough to another, and do not enable the creatures to pass from tree to tree after the manner of the larger flying phalangers and squirrels.

As it is only quite recently that anything has been recorded regarding the habits of the larger members of the family, we may conclude with an extract from a note published by Mr. W. H. Adams in the Proceedings of the Zoological Society, concerning Pel's flying squirrel (Anomalurus peli) from West Africa. The writer there states that these squiriels "come out of their holes in the trees some hours after sunset, returning long before daybreak. They are only to be seen on bright moonlight nights, and, in fact, the natives say they do not come out at all in stormy weather or on very dark nights. They live on berries and fruits, being specially fond of the palm oil nut, which they take to their nests to peel and eat. They pass from tree to tree with great rapidity, usually choosing to jump from a higher branch to a lower one, and then climbing up the tree to make a fresh start. The temperature on the hills varies considerably. During the time I was there—the rainy season, from the middle of April to the middle of June—it was never very hot, one night the thermometer going down to 44° on the ground. Of course, in the dry season it is much hotter, but the natives say these animals are much more plentiful in the rains, and that the rainier the season the more they see. They litter twice a year, once about September, the young remaining in the nest for about nine weeks, during which they are fed by the old ones on such food as shoots and kernels; they do not attempt to jump till the end of that period, extending the length of their jumps with their growth. I do not know the other time of breeding, or whether they have a regular season. The hunters told me that two or three were usually born at one birth, and never more than four."

Within the last few years an extraordinary number of new mammals have been discovered in Africa, some of the best known and most generally interesting being several large antelopes from Somaliland.

To the naturalist, however, a tiny little creature like the one under consideration, which represents a totally new type, is of far more interest than any antelope, whether the latter indicate a new genus or merely a new species. In Eastern Africa German and English zoologists and collectors are rivaling one another in the zeal with which new or rare forms are brought to light, but on the West Coast our German cousins seem to be having it all their own way. Although we should be the last to envy them the discovery of this latest addition to the mammalian fauna of West Africa, we cannot help expressing a hope that our own countrymen will not allow themselves to be outstripped in the race of discovery and collecting.

PROFESSOR SILVANUS P. THOMPSON, F.R.S., lecturing recently on the arc lamp at the Society of Arts, said that most of the total light of an arc lamp is given off from the crater, less than 10 per cent. coming from the peak. The crater may be regarded as a flat, self-luminous area. If it could be seen in such a way that the peak never came between it and the eye, it would give the greatest light when looked at perpendicularly, and the least when the line of vision was horizontal with its surface. But the shadow of the peak has to be reckoned with, and it is found that the light given off is directly proportional to the area of crater actually exposed to view, being greatest at an angle of 40 deg. or 50 deg. In the middle of the crater there may sometimes be discovered with the unaided eye a nebulous patch, rather whiter than the rest, which seems to be in motion. By the use of appropriate artificial means this patch may be seen as a comma-shaped object which rotates round the crater at very varying speeds and not always in the same direction. It is a question whether this is a true physical rotation of the flame or only an optical effect.

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